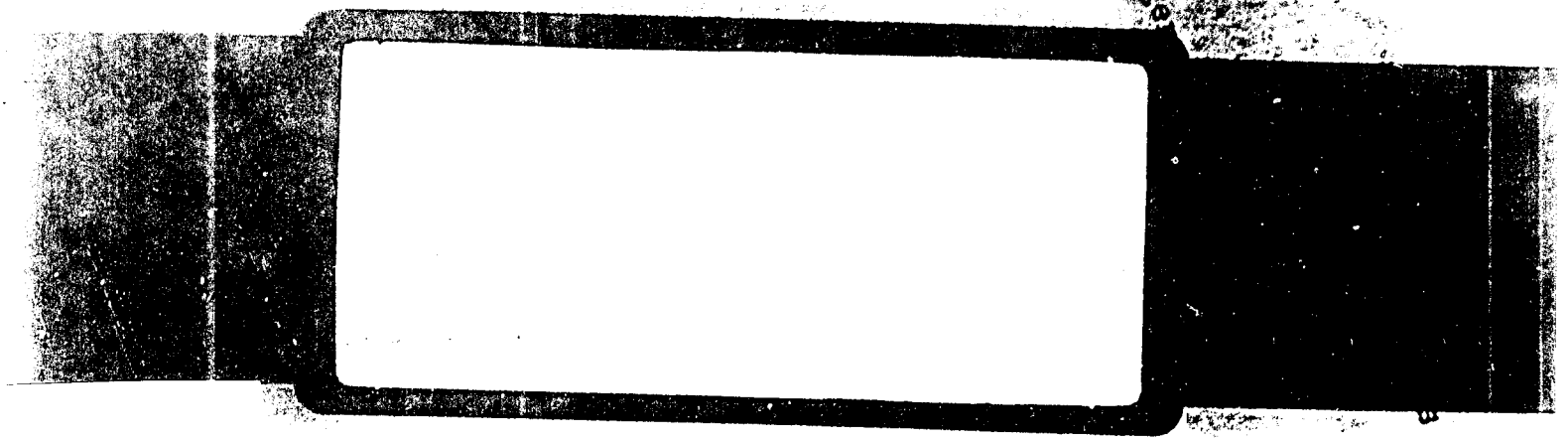

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The Air Force High School Apprenticeship Program's purpose is to place outstanding high school students whose interests are in the areas of mathematics, engineering, and science to work in a laboratory environment. The students selected to participate work in an Air Force Laboratory for a duration of 8 weeks during their summer vacation.

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UNITED STATES AIR FORCE

HIGH SCHOOL APPRENTICESHIP PROGRAM

1990

PROGRAM MANAGEMENT REPORT

VOLUME IV OF IV

UNIVERSAL ENERGY SYSTEMS, INC.

Program Director, UES
Rodney C. Darrah

Program Administrator, UES
Susan K. Espy

Program Manager, AFOSR
Lt. Col. Claude Cavender

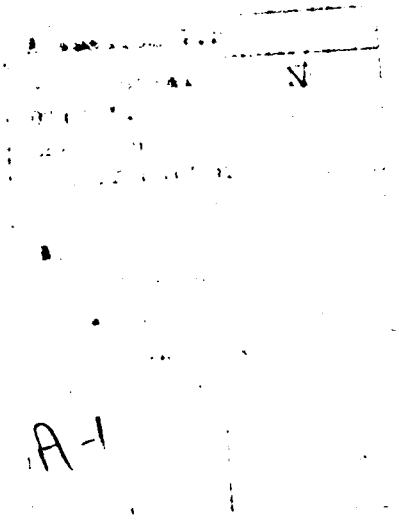
Submitted to

Air Force Office of Scientific Research

Bolling Air Force Base

Washington, DC

December 1990



A-1

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INTRODUCTION

In the near future the United States may face shortages of scientists and engineers in fields such as physics, electronic engineering, computer science and aeronautical engineering. High school students are currently not selecting to prepare for careers in these areas in numbers large enough to match the projected needs in the United States.

The Air Force faces "a formidable challenge - the acquisition and retention of the technological competence needed to ensure a strong national security, both in-house and in the industrial and academic base which supports defense preparedness." The Director of the Office and Science of Technology Policy in the Executive Office of the President in 1979 responded to this need by requesting the federal agencies to incorporate in their contract research programs the mechanisms to stimulate career interests in science and technology in high school students showing promise in these areas. The Air Force High School Apprenticeship Program is an example of the response to this.

Under the Special Studies section of the Summer Faculty Research Program an Air Force High School Apprenticeship was initiated. This program's purpose is to place outstanding high school students whose interests are in the areas of engineering and science to work in a laboratory environment. The students who were selected to participate worked in one of the Air Force Laboratories for a duration of 8 weeks during their summer vacation.

There has been a few incidents concerning misuse of the computers in the laboratories. On two separate occasions the laboratory has had to revoke computer privileges on four high school students. Both of these incidents happened at the same laboratory.

Two years ago two students wrote a program to shut down the computer system at the laboratory and to steal users access codes. These students were removed from the laboratory and one of the students was dismissed from the program, while the other student finished his apprenticeship at the UES facility.

This year a similar incident happened. Two other students were involved with basically the same incident. One student wrote a program that would send repeating messages to the various computer terminals. Included in this program was a password interception program were the users would type in their password and the program would retrieve that password. The other student involved also wrote and executed a password stealing program, and was involved in the unauthorized use of a government computer in writing a fraudulent letter. The student also obtained unauthorized access to a computer modem.

The Air Force High School Apprenticeship Program was modeled after the Army's High School Program, which is very successful.

The following time schedule was used in order to accomplish this effort.

TABLE 1
AIR FORCE HIGH SCHOOL
APPRENTICESHIP PROGRAM

Calendar of Activities

December	o Identify schools and laboratories for participation o Prepare informational material for schools and installations application forms for students and mentors, and covering letters. o Disseminate information o Recruit apprentices, mentors
January	o Send student applications to teachers
February	o Applications with teacher recommendations o Receive mentors' project descriptions and student requirements o Make preliminary selection of students for referral to mentor
March	o Make preliminary matching of students with mentors; send letters with several student applications to each mentor o Mentors interview students, inform UES of choice
April	o Send letters of placement to students, with acceptance forms to be signed by them and parents and returned to UES o Place 2nd year apprentices o Make final matches o See that security clearances are started, where applicable o (Mentors provide background reference material to chosen apprentices) o Encourage enrichment activities: arrange for films, speakers, tours, etc.
May	o Send letters to students and mentors re-opening session o Send students Apprentice Handbook
June	o Arrange general orientation for students and mentors
July, August	o Administer and monitor apprenticeships o Check on enrichment activities o Distribute evaluation forms to students and mentors
September	o Analyze evaluations o Prepare final report to Air Force

RECRUITING AND SELECTION

Application packages and the flyer were distributed to the laboratories and to the various high schools within convenient driving distance of the laboratories (typically less than 20 miles).

There was a total of 516 applications received by UES on the program. When the applications were received, a copy was sent to the appropriate laboratory for review. The laboratory mentor screened the applications and conducted personnel interviews with the high school students then sent UES a prioritized list of their applicants. There were a total of 132 participants on the program, selected from the 516 applications.

The laboratories participating in the program along with the number of students assigned to the laboratory is listed below:

Aero Propulsion Laboratory	7
Armament Laboratory	16
Armstrong Aerospace Medical Research Laboratory	7
Arnold Engineering and Development Center	6
Avionics Laboratory	6
Astronautics Laboratory	12
Engineering and Services Center	15
Electronic Technology Laboratory	5
Flight Dynamics Laboratory	9
Geophysics Laboratory	7
Materials Laboratory	1
Occupational and Environmental Health Laboratory	3
Rome Air Development Center	15
School of Aerospace Medicine	13
Weapons Laboratory	10

Participant Laboratory Assignment
1990 High School Apprenticeship Program

Aero Propulsion Laboratory
Wright-Patterson Air Force Base, Ohio

1. Matthew Bold
2. Hee Sun Choung
3. Katharine Day
4. Chris Hatch
5. Chet Nieter
6. Jennifer Pollock
7. Carol Rogers

Armament Laboratory
Eglin Air Force Base, Florida

1. Steven Bryan
2. Toyna Cook
3. Heather Cox
4. Kathryn Deibler
5. Chris Ellis
6. Dana Farver
7. Kenneth Gage
8. Reid Harrison
9. Derek Holland
10. Christine Riendeau
11. Lisa Schmidt
12. Patricia Tu
13. Troy Urquhart
14. Gregory VanWiggeren
15. Danielle Walker
16. Eric White

Armstrong Aerospace Medical Research Laboratory
Wright-Patterson Air Force Base, Ohio

1. Rex Ballinger
2. Douglas Brungart
3. Caroline Chuang
4. Keisha Hayes
5. Douglas Marshak
6. Jeremiah Rogers
7. James Shamiyeh

Arnold Engineering and Development Center
Arnold Air Force Base, Tennessee

1. Timothy Craddock
2. Myra Medley
3. Julie Reece
4. Jonathan Sanders
5. Jason Scott
6. Gerald Turner

Astronautics Laboratory
Edwards Air Force Base, California

1. Alisha Conrow
2. Debra Meyer
3. John Moro
4. Lloyd Neurauter
5. Joseph Padilla
6. Melanie Pyle
7. Thomas Quinn
8. Tracy Reed
9. Benjamin Sommers
10. Stephanie VanMeter
11. Rebecca Weston
12. David Youmans

Avionics Laboratory
Wright-Patterson Air Force Base, Ohio

1. Brian Barclay
2. Mark Boeke
3. Michael Chabinyc
4. David Collins
5. Austin Flack
6. Jerard Wilson

Engineering and Services Center
Tyndall Air Force Base, Florida

1. Jennifer Brewer
2. Philip Dorsch
3. David Eshleman
4. Richard Hartzer
5. Thor Johnson
6. Tracy Lamb
7. Brent Miller
8. Debra Piechowiak
9. Jonathan Protz
10. Julie Scruggs
11. Michael Stone
12. Amy Thomas
13. Michael Thompson
14. Jeffrey Ward
15. Robin Woodworth

Electronic Technology Laboratory
Wright-Patterson Air Force Base, Ohio

1. Matthew Brewer
2. Matt Elwood
3. Shelly Knupp
4. Christopher O'Dell
5. Suzette Yu

Flight Dynamics Laboratory
Wright-Patterson Air Force Base, Ohio

1. Jean Ay
2. Matthew Becker
3. Wendy Choate
4. Andrea Dean
5. Rachael Lyon
6. Cathie Moore
7. Roderick Morgan
8. Stanley Wall
9. Douglas Wickert

Geophysics Laboratory
Hanscom Air Force Base, Massachusetts

1. Stephen Britten
2. Weihaw Chuang
3. Christopher Guild
4. Jason Klingensmith
5. Galen McKinley
6. Jeffrey Sayasane
7. Paul Swietek

Materials Laboratory
Wright-Patterson Air Force Base, Ohio

1. Jennifer Walker

Occupational and Environment Health Laboratory
Brooks Air Force Base, Texas

1. Gary New
2. Andrea Perez
3. Michael Smid

Rome Air Development Center
Griffiss Air Force Base, New York

1. Daniel Abbis
2. Mark Anania
3. Bridget Bordiuk
4. Todd Gleason
5. Christopher Hailes
6. Edward Holmes
7. Kimberly King
8. Kathryn Lee
9. Jason Lenio
10. Kevin Olson
11. David Petrillo
12. Thomas Potter
13. Daniel Russell
14. Philip Schremmer
15. Eric Shaw

School of Aerospace Medicine
Brooks Air Force Base, Texas

1. Anthony Barnes
2. Whitney Brandt
3. Deann Cooper
4. Matthew Felder
5. Christopher Hudson
6. Sonya Longbotham
7. Brian McBurnett
8. Heather Neville
9. Lori Olenick
10. Joanna Saucedo
11. Wendy Shields
12. Brent Strawn
13. John Taboada

Weapons Laboratory
Kirtland Air Force Base, New Mexico

1. David Cochrell
2. Gregory Hays
3. David Knapp
4. Aaron Laing
5. Kerim Martinez
6. Ryan McAlhaney
7. Margaret Morecock
8. Philip Ortiz
9. Brian Rizzoli
10. Chris Stoltenberg

INFORMATION PACKAGE

23 March 1990

Dear :

Enclosed are the mentor applications forms for the 1990 USAF High School Apprenticeship Program. The mentors and project descriptions have been approved by UES.

Enclosed are the applications for the High School Apprenticeship program for the summer of 1990. The following mentors and previous high school participants have been matched and selected to work with each other for the coming summer.

	Student	Mentor
1.		
2.		
3.		

The following is a previous high school participant in the program and is selected to participate in the program for this summer. He needs to be matched with one of the approved mentors for this summer.

	Student
1.	

The remainder of the students need to be evaluated by the approved mentors for possible selection in the program for this summer. Please provide to UES a listing of the mentor recommendations for students by 15 April 1990.

We have a total of 100 positions available on the program for this summer. We will select as many as possible to fill this available positions. We anticipate that about 15 high school students will be selected to participate with the mentors at the Rome Air Development Center.

If you have any questions concerning this information, please do not hesitate to contact us.

Sincerely,

UNIVERSAL ENERGY SYSTEMS, INC.

Rodney C. Darrah
Program Director

Enclosure

xc: Lt. Col. Claude Cavender

MODEL PLACEMENT LETTER TO STUDENT

13 March 1991

1~
2~
3~

Dear 4~:

Congratulations! You have been selected to participate in the Air Force Office of Scientific Research High School Apprenticeship Program as an apprentice to 5~ at the 6~ to work on Project: "7~ " from June 18 to August 10, 1990. Enclosed is an acceptance form for you and your parent or guardian to sign. Also enclosed is your W-4 form which needs to be filled out and returned along with your acceptance form to me by May 11, 1990.

The Apprenticeship Program provides an exciting opportunity for you, and we hope you will take advantage of the work experience to learn more about scientific research, career opportunities in science and engineering, and the education necessary to prepare yourself for such careers. On June 18, 1990, the first day of the program, you are expected to attend an orientation session with other apprentices and mentors and to ask questions about any concerns you might have. Many of those concerns are discussed in the Apprentice Handbook which is enclosed. The Handbook also contains suggestions for getting the most out of the summer experience, and references to other work experience programs and financial assistance available for college education. Please read the Handbook before the orientation session, so that time will not be used for questions answered in the book.

You will be expected to begin work promptly at 8:00 a.m. on June 18. If for any reason you cannot begin work on that day, or cannot report to work on any future work day, you must inform your mentor at 8~.

We hope you will enjoy your apprenticeship. I will be available throughout the summer should problems arise that cannot be solved by your mentor.

Sincerely,

UNIVERSAL ENERGY SYSTEMS, INC.

Rodney C. Darrah
Program Director

RCD/mt

STUDENT ACCEPTANCE FORM

for participation in

Air Force Office of Scientific Research

High School Apprenticeship Program, 1990

I, 1~, accept the position of apprentice in the Air Force Office of Scientific Research High School Apprenticeship Program from June 18, 1990 to August 10, 1990 to work with 2~ at the 3~ on Project: "4~". I understand that I will receive a stipend of $5~ for the summer apprenticeship for which I must participate during the entire session.

_____ _____

Date Signature of student

_____

High School

PARENT CONSENT

As the parent/guardian, I certify that my son/daughter/ward has my permission to participate in this project for secondary school students. It is my understanding that he/she will be subject to the regulations of the host institution and the project. I understand that should a health emergency arise I will be notified, but that if I cannot be reached by telephone, such medical treatment as deemed necessary by competent medical personnel is authorized.

_____ _____

Date Signature of parent

_____

Daytime phone

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
MENTOR EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A MENTOR)

1. How did you hear about program?

   o Previous mentor
   o Notice on bulletin board
   o Memo from personnel office
   o Verbal request from personnel office
   o Other, specify_____

2. Did you volunteer to be a mentor?

   Yes___ No___

3. Did the student application provide sufficient information?

   Yes___ No___

4. If no, what additional information would you want to see included on the student application form?_____

5. Did you interview the student who was placed in your laboratory before the program started?

   Yes___ No___

6. If no, would an interview have been useful?

   Yes___ No___

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

   A lot___ Some___ Not at all___

8. How much did the student contribute to the research of your laboratory?

   A lot___ Some___ Not at all___

9. How would you rate the student's performance?

   Excellent___ Fair___ Poor___

10. Would like to participant as a mentor for the program next summer?

Yes___ No___ If No, Why?_____

11. Would you want the same student in your laboratory next summer?

Yes___ No___ If No, Why?_____

12. Did the work of the student influence his/her choice of

a. courses in coming school year? __Yes ___No ___Don't know

Explain _____

b. career choice? ___Yes ___No ___Don't know

Explain _____

If you have suggestions or comments on the program, please use the space below.

PLEASE RETURN BY 14 September 1990

to: Susan Espy
Coordinator

Universal Energy Systems
4401 Dayton-Xenia Road
Dayton, OH 45432
Address

_____
Name of student apprentice

_____
Name of mentor/laboratory

_____
Date

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
MENTOR EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A MENTOR)

AERO PROPULSION LABORATORY

1. How did you hear about program?

   6 Previous mentor
   0 Notice on bulletin board
   0 Memo from personnel office
   0 Verbal request from personnel office
   1 Other, specify:_____

   Assistant Chief Scientists.

2. Did you volunteer to be a mentor?

   7 Yes
   0 No

3. Did the student application provide sufficient information?

   7 Yes
   0 No
   0 Don't Know

4. If no, what additional information would you want to see included on the student application form?

   Specific information regarding computer experience.

5. Did you interview the student who was placed in your laboratory before the program started?

   4 Yes
   3 No

6. If no, would an interview have been useful?

   6 Yes
   1 No

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

   6 A lot
   1 Some
   0 Not at all

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

   6 A lot
   1 Some
   0 Not at all

8. How much did the student contribute to the research of your laboratory?

   2 A lot
   5 Some
   0 Not at all

9. How would you rate the student's performance?

   4 Excellent
   3 Fair
   0 Poor

10. Would like to participant as a mentor for the program next summer?

    7 Yes
    0 No
      If No, Why?

11. Would you want the same student in your laboratory next summer?

    7 Yes
    0 No
      If No, Why?

12. Did the work of the student influence his/her choice of

    a. courses in coming school year? 0 - Yes 1 - No 6 - Don't Know

       Explain:

       She was already planning on an Engineering degree at U. of K.

    b. career choice? 0 - Yes 1 - No 6 - Don't know

       Explain:

If you have suggestions or comments on the program, please use the space below.

PLEASE RETURN BY 14 September 1990

to: Susan Espy
Coordinator

Universal Energy Systems
4401 Dayton-Xenia Road
Dayton, OH 45432
Address

_____
Name of student apprentice

_____
Name of mentor/laboratory

_____
Date

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
MENTOR EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A MENTOR)

ARMAMENT LABORATORY

1. How did you hear about program?

   11 Previous mentor
   0 Notice on bulletin board
   3 Memo from personnel office
   0 Verbal request from personnel office
   2 Other, specify:_____

   Section Chief.

   I have been a mentor for 3 years.

2. Did you volunteer to be a mentor?

   16 Yes
   0 No

3. Did the student application provide sufficient information?

   12 Yes
   1 No
   3 N/A

4. If no, what additional information would you want to see included on the student application form?

   I did not see the application, or pay much attention to it. I just accepted the student assigned to me.

5. Did you interview the student who was placed in your laboratory before the program started?

   10 Yes
   6 No

6. If no, would an interview have been useful?

   5 Yes
   0 No

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

    15 A lot
    1 Some
    0 Not at all

8. How much did the student contribute to the research of your laboratory?

    10 A lot
    6 Some
    0 Not at all

9. How would you rate the student's performance?

    15 Excellent
    1 Fair
    0 Poor

10. Would like to participant as a mentor for the program next summer?

    14 Yes
    2 No
    If No, Why?

    I will be away.

11. Would you want the same student in your laboratory next summer?

    10 Yes
    6 No
    If No, Why?

    All the no responses indicate the students will be attending college and not eligible for the program.

12. Did the work of the student influence his/her choice of

    a. courses in coming school year? 5 - Yes 2 - No 9 - Don't know

    Explain:

    Most of the comments indicate that the courses are already set. But toward the math and science courses.

b. career choice? 7 - Yes 1 - No 8 - Don't know

Explain:

The comments consist that students are still deciding, two of the students definitely want in the science careers.

If you have suggestions or comments on the program, please use the space below.

PLEASE RETURN BY 14 September 1990

_____
Name of student apprentice

to: Susan Espy
Coordinator

_____
Name of mentor/laboratory

Universal Energy Systems
4401 Dayton-Xenia Road
Dayton, OH 45432
Address

_____
Date

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
MENTOR EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A MENTOR)

ARMSTRONG AEROSPACE MEDICAL RESEARCH LABORATORY

1. How did you hear about program?

   7 Previous mentor
   0 Notice on bulletin board
   0 Memo from personnel office
   0 Verbal request from personnel office
   0 Other, specify:_____

2. Did you volunteer to be a mentor?

   7 Yes
   0 No

3. Did the student application provide sufficient information?

   6 Yes
   0 No

4. If no, what additional information would you want to see included on the student application form?

   I didn't see the application form.

5. Did you interview the student who was placed in your laboratory before the program started?

   2 Yes
   5 No

6. If no, would an interview have been useful?

   2 Yes
   2 No

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

   3 A lot
   4 Some
   0 Not at all

8. How much did the student contribute to the research of your laboratory?

   2 A lot
   5 Some
   0 Not at all

9. How would you rate the student's performance?

   6 Excellent
   1 Fair
   0 Poor

10. Would like to participant as a mentor for the program next summer?

    4 Yes
    0 No
      If No, Why?

11. Would you want the same student in your laboratory next summer?

    6 Yes
    1 No
      If No, Why?

    She graduated.

12. Did the work of the student influence his/her choice of

    a. courses in coming school year? 2 - Yes 1 - No 4 - Don't know

       Explain:

       Gained additional knowledge & training in lab that allowed testing out of some pre-requisite courses.

    b. career choice? 2 - Yes 2 - No 3 - Don't know

       Explain:

       Comments include that the student has new insight to engineering, and another student wants to go into medicine

If you have suggestions or comments on the program, please use the space below.

PLEASE RETURN BY 14 September 1990

to: Susan Espy
Coordinator

Universal Energy Systems
4401 Dayton-Xenia Road
Dayton, OH 45432
Address

_____
Name of student apprentice

_____
Name of mentor/laboratory

_____
Date

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
MENTOR EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A MENTOR)

ARNOLD ENGINEERING AND DEVELOPMENT CENTER

1. How did you hear about program?

   1 Previous mentor
   0 Notice on bulletin board
   2 Memo from personnel office
   2 Verbal request from personnel office
   1 Other, specify:_____

   Supervisor.

2. Did you volunteer to be a mentor?

   5 Yes
   1 No

3. Did the student application provide sufficient information?

   6 Yes
   0 No

4. If no, what additional information would you want to see included on the student application form?

5. Did you interview the student who was placed in your laboratory before the program started?

   4 Yes
   2 No

6. If no, would an interview have been useful?

   1 Yes
   1 No
   0 Maybe

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

   4 A lot
   2 Some
   0 Not at all

8. How much did the student contribute to the research of your laboratory?

   4 A lot
   2 Some
   0 Not at all

9. How would you rate the student's performance?

   6 Excellent
   0 Fair
   0 Poor

10. Would like to participant as a mentor for the program next summer?

    6 Yes
    0 Maybe
    0 No
      If No, Why?

11. Would you want the same student in your laboratory next summer?

    6 Yes
    0 No
      If No, Why?

12. Did the work of the student influence his/her choice of

    a. courses in coming school year? 1 - Yes 3 - No 2 - Don't know

       Explain:

       The no responses indicate that courses are pre-determined and not many options.

    b. career choice? 4 - Yes 0 - No 2 - Don't know

       Explain:

       Heightened interest in chemistry/chemical engineering.

       Solidified his intent to pursue an engineering career.

If you have suggestions or comments on the program, please use the space below.

I would suggest that students requiring a security clearance he given advanced notice so that the necessary processing could be completed prior to their coming to work. A ten week program (instead of 8) should be offered as an option for the students.

This program was a very positive experience for me as well as her. I would enjoy participating in the program again.

PLEASE RETURN BY 14 September 1990

_____
Name of student apprentice

to: Susan Espy
Coordinator

_____
Name of mentor/laboratory

Universal Energy Systems
4401 Dayton-Xenia Road
Dayton, OH 45432
Address

_____
Date

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
MENTOR EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A MENTOR)

ASTRONAUTICS LABORATORY

1. How did you hear about program?

   5 Previous mentor
   0 Notice on bulletin board
   1 Memo from personnel office
   1 Verbal request from personnel office
   2 Other, specify:_____

   Request from XRX.

2. Did you volunteer to be a mentor?

   9 Yes
   0 No

3. Did the student application provide sufficient information?

   8 Yes
   1 No

4. If no, what additional information would you want to see included on the student application form?

   At a high school level there isn't a lot of detailed scientific technical questions you can ask for.

5. Did you interview the student who was placed in your laboratory before the program started?

   4 Yes
   5 No

6. If no, would an interview have been useful?

   4 Yes
   1 No

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

   7 A lot
   2 Some
   0 Not at all

8. How much did the student contribute to the research of your laboratory?

   6 A lot
   3 Some
   0 Not at all

9. How would you rate the student's performance?

   9 Excellent
   0 Fair
   0 Poor

10. Would like to participant as a mentor for the program next summer?

    9 Yes
    0 No
      If No, Why?

11. Would you want the same student in your laboratory next summer?

    9 Yes
    0 No
      If No, Why?

12. Did the work of the student influence his/her choice of

    a. courses in coming school year? 2 - Yes 4 - No 3 - Don't know

       Explain:

       Most of the responses indicate that student's courses are already set for the upcoming year.

    b. career choice? 1 - Yes 3 - No 5 - Don't know

       Explain:

       Two of the comments were that the student's have their career's planned, even as far as job opportunities. One student wants to go in the medical profession.

If you have suggestions or comments on the program, please use the space below.

Let the students accrue leave (annual & sick) and let them work more than 40 days!

PLEASE RETURN BY 14 September 1990

to: Susan Espy
Coordinator

Universal Energy Systems
4401 Dayton-Xenia Road
Dayton, OH 45432
Address

_____
Name of student apprentice

_____
Name of mentor/laboratory

_____
Date

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
MENTOR EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A MENTOR)

AVIONICS LABORATORY

1. How did you hear about program?

   3 Previous mentor
   1 Notice on bulletin board
   1 Memo from personnel office
   1 Verbal request from personnel office
   0 Other, specify:_____

2. Did you volunteer to be a mentor?

   6 Yes
   0 No

3. Did the student application provide sufficient information?

   4 Yes
   2 No

4. If no, what additional information would you want to see included on the student application form?

   Previous police record and descriptions of any court imposed fines or punishment.

5. Did you interview the student who was placed in your laboratory before the program started?

   0 Yes
   6 No

6. If no, would an interview have been useful?

   2 Yes
   4 No

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

   2 A lot
   4 Some
   0 Not at all

8. How much did the student contribute to the research of your laboratory?

   4 A lot
   2 Some
   0 Not at all

9. How would you rate the student's performance?

   5 Excellent
   0 Fair
   1 Poor

10. Would like to participant as a mentor for the program next summer?

    5 Yes
    1 No
      If No, Why?

11. Would you want the same student in your laboratory next summer?

    5 Yes
    1 No
      If No, Why?

12. Did the work of the student influence his/her choice of

    a. courses in coming school year? 1 - Yes 3 - No 2 - Don't know

       Explain:

       I think his courses were pretty well planned out before he came to the lab. What he learned here probably reinforced his choices rather than changing them.

    b. career choice? 2 - Yes 2 - No 2 - Don't know

       Explain:

       All of the responses indicate the students' have chosen a career; from chemical engineer to computer science.

If you have suggestions or comments on the program, please use the space below.

PLEASE RETURN BY 14 September 1990

to: Susan Espy
Coordinator

Universal Energy Systems
4401 Dayton-Xenia Road
Dayton, OH 45432
Address

_____
Name of student apprentice

_____
Name of mentor/laboratory

_____
Date

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
MENTOR EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A MENTOR)

ENGINEERING AND SERVICES CENTER

1. How d'd you hear about program?

   9 Previous mentor
   1 Notice on bulletin board
   0 Memo from personnel office
   1 Verbal request from personnel office
   4 Other, specify:_____

   The comments for the Other category were notifications from AFESC staff.

2. Did you volunteer to be a mentor?

   14 Yes
   1 No

3. Did the student application provide sufficient information?

   14 Yes
   1 No

4. If no, what additional information would you want to see included on the student application form?

   Never saw a student application from.

5. Did you interview the student who was placed in your laboratory before the program started?

   4 Yes
   11 No

6. If no, would an interview have been useful?

   8 Yes
   4 No

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

   9 A lot
   5 Some
   1 Not at all

8. How much did the student contribute to the research of your laboratory?

   9 A lot
   5 Some
   1 Not at all

9. How would you rate the student's performance?

   14 Excellent
   1 Fair
   0 Poor

10. Would like to participant as a mentor for the program next summer?

    13 Yes
    2 No
      If No, Why?

    The "no" comments were because of the time that it takes, and the other mentor will be traveling.

11. Would you want the same student in your laboratory next summer?

    15 Yes
    0 No
      If No, Why?

    If I were to do it again.

12. Did the work of the student influence his/her choice of

    a. courses in coming school year? 5 - Yes 4 - No 6 - Don't know

       Explain:

       The majority of the comments as before where that the courses are already determined.

    b. career choice? 4 - Yes 3 - No 8 - Don't know

       Explain:

       The comments range from students that have not decided, to a student choosing to be an engineer and Air Force pilot.

If you have suggestions or comments on the program, please use the space below.

PLEASE RETURN BY 14 September 1990

_____
Name of student apprentice

to: Susan Espy
Coordinator

_____
Name of mentor/laboratory

Universal Energy Systems
4401 Dayton-Xenia Road
Dayton, OH 45432
Address

_____
Date

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
MENTOR EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A MENTOR)

ELECTRONIC TECHNOLOGY LABORATORY

1. How did you hear about program?

   0 Previous mentor
   0 Notice on bulletin board
   1 Memo from personnel office
   0 Verbal request from personnel office
   4 Other, specify:_____

   Through Lab Operation Division (ELA).

   Verbal request from boss.

   Co-worker.

2. Did you volunteer to be a mentor?

   4 Yes
   1 No

3. Did the student application provide sufficient information?

   5 Yes
   0 No

4. If no, what additional information would you want to see included on the student application form?

5. Did you interview the student who was placed in your laboratory before the program started?

   3 Yes
   2 No

6. If no, would an interview have been useful?

   1 Yes
   1 No

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

   5 A lot
   0 Some
   0 Not at all

8. How much did the student contribute to the research of your laboratory?

   3 A lot
   2 Some
   0 Not at all

9. How would you rate the student's performance?

   4 Excellent
   1 Fair
   0 Poor

10. Would like to participant as a mentor for the program next summer?

    5 Yes
    0 No
      If No, Why?

11. Would you want the same student in your laboratory next summer?

    4 Yes
    1 No
      If No, Why?

    Student has limited interest in research.

12. Did the work of the student influence his/her choice of

    a. courses in coming school year? 0 - Yes 1 - No 4 - Don't know

       Explain:

       Responses indicate that courses are pre-determined.

    b. career choice? 0 - Yes 0 - No 5 - Don't know

       Explain:

       I think she has gained an appreciation for the challenging nature of research.

If you have suggestions or comments on the program, please use the space below.

PLEASE RETURN BY 14 September 1990

to: Susan Espy
Coordinator

Universal Energy Systems
4401 Dayton-Xenia Road
Dayton, OH 45432
Address

_____
Name of student apprentice

_____
Name of mentor/laboratory

_____
Date

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
MENTOR EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A MENTOR)

FLIGHT DYNAMICS LABORATORY

1. How did you hear about program?

   4 Previous mentor
   0 Notice on bulletin board
   0 Memo from personnel office
   1 Verbal request from personnel office
   3 Other, specify:_____

   Branch office.

   WRDC/FIOP

2. Did you volunteer to be a mentor?

   8 Yes
   0 No

3. Did the student application provide sufficient information?

   8 Yes
   0 No

4. If no, what additional information would you want to see included on the student application form?

5. Did you interview the student who was placed in your laboratory before the program started?

   3 Yes
   5 No

6. If no, would an interview have been useful?

   4 Yes
   1 No

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

   5 A lot
   3 Some
   0 Not at all

8. How much did the student contribute to the research of your laboratory?

   5 A lot
   3 Some
   0 Not at all

9. How would you rate the student's performance?

   7 Excellent
   1 Fair
   0 Poor

10. Would like to participant as a mentor for the program next summer?

    7 Yes
    1 No
      If No, Why?

    Only if a project is available for use by student!

11. Would you want the same student in your laboratory next summer?

    6 Yes
    2 No
      If No, Why?

    Comments indicate student's are not eligible.

12. Did the work of the student influence his/her choice of

    a. courses in coming school year? 1 - Yes 2 - No 5 - Don't know

       Explain:

       Student had already chosen Engineering Curriculum for College.

    b. career choice? 3 - Yes 1 - No 4 - Don't know

       Explain:

       Student already targets Aerospace future.

If you have suggestions or comments on the program, please use the space below.

Work must be available that a student can get involved in for the duration of there stay. If it is not, I will not take any more students.

PLEASE RETURN BY 14 September 1990

_____
Name of student apprentice

to: Susan Espy
Coordinator

_____
Name of mentor/laboratory

Universal Energy Systems
4401 Dayton-Xenia Road
Dayton, OH 45432
Address

_____
Date

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
MENTOR EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A MENTOR)

GEOPHYSICS LABORATORY

1. How did you hear about program?

   2 Previous mentor
   0 Notice on bulletin board
   3 Memo from personnel office
   0 Verbal request from personnel office
   0 Other, specify:_____

2. Did you volunteer to be a mentor?

   5 Yes
   0 No

3. Did the student application provide sufficient information?

   5 Yes
   0 No

4. If no, what additional information would you want to see included on the student application form?

5. Did you interview the student who was placed in your laboratory before the program started?

   1 Yes
   4 No

6. If no, would an interview have been useful?

   3 Yes
   1 No

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

   3 A lot
   2 Some
   0 Not at all

8. How much did the student contribute to the research of your laboratory?

   3 A lot
   2 Some
   0 Not at all

9. How would you rate the student's performance?

   5 Excellent
   0 Fair
   0 Poor

10. Would like to participate as a mentor for the program next summer?

    5 Yes
    0 No
      If No, Why?

11. Would you want the same student in your laboratory next summer?

    5 Yes
    0 No
      If No, Why?

12. Did the work of the student influence his/her choice of

    a. courses in coming school year? 0 - Yes 0 - No 5 - Don't know

       Explain:

       Courses probably selected prior to the summer job.

    b. career choice? 0 - Yes 1 - No 4 - Don't know

       Explain:

       Was already planning to enter MIT in an engineering field.

If you have suggestions or comments on the program, please use the space below.

The main comment is that they would like to see the program expanded to 10 to 12 weeks, also that the stipend should be raised to compete with jobs outside of research.

PLEASE RETURN BY 14 September 1990

_____
Name of student apprentice

to: Susan Espy
Coordinator

_____
Name of mentor/laboratory

Universal Energy Systems
4401 Dayton-Xenia Road
Dayton, OH 45432
Address

_____
Date

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
MENTOR EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A MENTOR)

MATERIALS LABORATORY

1. How did you hear about program?

   0 Previous mentor
   0 Notice on bulletin board
   0 Memo from personnel office
   1 Verbal request from personnel office
   0 Other, specify:_____

2. Did you volunteer to be a mentor?

   1 Yes
   0 No

3. Did the student application provide sufficient information?

   1 Yes
   0 No

4. If no, what additional information would you want to see included on the student application form?

5. Did you interview the student who was placed in your laboratory before the program started?

   0 Yes
   1 No

6. If no, would an interview have been useful?

   1 Yes
   0 No

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

   1 A lot
   0 Some
   0 Not at all

8. How much did the student contribute to the research of your laboratory?

   1 A lot
   0 Some
   0 Not at all

9. How would you rate the student's performance?

   1 Excellent
   0 Fair
   0 Poor

10. Would like to participant as a mentor for the program next summer?

    1 Yes
    0 No
      If No, Why?

11. Would you want the same student in your laboratory next summer?

    1 Yes
    0 No
      If No, Why?

12. Did the work of the student influence his/her choice of

    a. cc ırses in coming school year? 0 - Yes 0 - No 1 - Don't know

       Explain:

       Student is pursuing a career in Civil Engineering.

    b. career choice? 0 - Yes 1 - No 0 - Don't know

       Explain:

If you have suggestions or comments on the program, please use the space below.

She was really a pleasure to work with. She was self motivated and a diligent worker who was genuinely interested in everything going on within the lab. She did a outstanding job. Would like to see her back next year!

PLEASE RETURN BY 14 September 1990

to: Susan Espy
Coordinator

Universal Energy Systems
4401 Dayton-Xenia Road
Dayton, OH 45432
Address

Name of student apprentice

Name of mentor/laboratory

Date

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
MENTOR EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A MENTOR)

OCCUPATIONAL AND ENVIRONMENT HEALTH LABORATORY

1. How did you hear about program?

   0 Previous mentor
   0 Notice on bulletin board
   1 Memo from personnel office
   0 Verbal request from personnel office
   1 Other, specify:_____

   My supervisor.

2. Did you volunteer to be a mentor?

   1 Yes
   1 No

3. Did the student application provide sufficient information?

   2 Yes
   0 No

4. If no, what additional information would you want to see included on the student application form?

5. Did you interview the student who was placed in your laboratory before the program started?

   0 Yes
   2 No

6. If no, would an interview have been useful?

   2 Yes
   0 No

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

   0 A lot
   2 Some
   0 Not at all

8. How much did the student contribute to the research of your laboratory?

   2 A lot
   0 Some
   0 Not at all

9. How would you rate the student's performance?

   2 Excellent
   0 Fair
   0 Poor

10. Would like to participant as a mentor for the program next summer?

    2 Yes
    0 No
      If No, Why?

11. Would you want the same student in your laboratory next summer?

    2 Yes
    0 No
      If No, Why?

12. Did the work of the student influence his/her choice of

    a. courses in coming school year? 0 - Yes 0 - No 2 - Don't know

       Explain:

       Student was already interested in science courses.

    b. career choice? 0 - Yes 0 - No 2 - Don't know

       Explain:

       Student is already set to take engineering in college.

If you have suggestions or comments on the program, please use the space below.

PLEASE RETURN BY 14 September 1990

to: Susan Espy
Coordinator

Universal Energy Systems
4401 Dayton-Xenia Road
Dayton, OH 45432
Address

_____
Name of student apprentice

_____
Name of mentor/laboratory

_____
Date

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
MENTOR EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A MENTOR)

ROME AIR DEVELOPMENT CENTER

1. How did you hear about program?

   4 Previous mentor
   0 Notice on bulletin board
   3 Memo from personnel office
   2 Verbal request from personnel office
   2 Other, specify:_____

   Director of Photonics Labs.

   Branch Chief sent me a memo.

2. Did you volunteer to be a mentor?

   10 Yes
   1 No

3. Did the student application provide sufficient information?

   10 Yes
   1 No

4. If no, what additional information would you want to see included on the student application form?

5. Did you interview the student who was placed in your laboratory before the program started?

   0 Yes
   11 No

6. If no, would an interview have been useful?

   6 Yes
   5 No

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

   4 A lot
   7 Some
   0 Not at all

8. How much did the student contribute to the research of your laboratory?

   3 A lot
   8 Some
   0 Not at all

9. How would you rate the student's performance?

   10 Excellent
   1 Fair
   0 Poor

10. Would like to participant as a mentor for the program next summer?

    8 Yes
    3 No
    If No, Why?

    The "no" responses indicated that they did not have the time to devote to the students.

11. Would you want the same student in your laboratory next summer?

    8 Yes
    3 No
    If No, Why?

    Give someone else the opportunity to work here.

12. Did the work of the student influence his/her choice of

    a. courses in coming school year? 2 - Yes 2 - No 7 - Don't know

       Explain:

       Courses pre-determined but students were influenced for courses at the advanced levels.

    b. career choice? 3 - Yes 2 - No 5 - Don't know

       Explain:

       The majority of the comments were that the career choices were reinforced.

If you have suggestions or comments on the program, please use the space below.

Great Program! Thanks!

PLEASE RETURN BY 14 September 1990

to: Susan Espy
Coordinator

Universal Energy Systems
4401 Dayton-Xenia Road
Dayton, OH 45432
Address

_____
Name of student apprentice

_____
Name of mentor/laboratory

_____
Date

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
MENTOR EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A MENTOR)

SCHOOL OF AEROSPACE MEDICINE

1. How did you hear about program?

   7 Previous mentor
   1 Notice on bulletin board
   0 Memo from personnel office
   1 Verbal request from personnel office
   4 Other, specify:_____

   Laboratory Chief Scientist

   Letter from SAM/CA.

2. Did you volunteer to be a mentor?

   13 Yes
   0 No

3. Did the student application provide sufficient information?

   13 Yes
   0 No

4. If no, what additional information would you want to see included on the student application form?

5. Did you interview the student who was placed in your laboratory before the program started?

   4 Yes
   8 No

6. If no, would an interview have been useful?

   4 Yes
   4 No

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

   12 A lot
   1 Some
   0 Not at all

8. How much did the student contribute to the research of your laboratory?

   9 A lot
   4 Some
   0 Not at all

9. How would you rate the student's performance?

   11 Excellent
   2 Fair
   0 Poor

10. Would like to participant as a mentor for the program next summer?

    12 Yes
    0 No
      If No, Why?

11. Would you want the same student in your laboratory next summer?

    11 Yes
    2 No
      If No, Why?

    The student stated she did not have the patience for research work. Therefore, I would prefer giving another student an opportunity to participate in next year's program.

12. Did the work of the student influence his/her choice of

    a. courses in coming school year? 1 - Yes 3 - No 9 - Don't know

       Explain:

       The responses indicated that courses are pre-determined, although one comment indicated that it influenced the student's college courses.

    b. career choice? 5 - Yes 0 - No 8 - Don't know

       Explain:

       Indicated a change from nursing to biological research.

If you have suggestions or comments on the program, please use the space below.

This is an excellent program. It helps students realize what "research" means, and gives them some independence in the laboratory setting.

PLEASE RETURN BY 14 September 1990

to: Susan Espy
Coordinator

Universal Energy Systems
4401 Dayton-Xenia Road
Dayton, OH 45432
Address

Name of student apprentice

Name of mentor/laboratory

Date

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
MENTOR EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A MENTOR)

WEAPONS LABORATORY

1. How did you hear about program?

   1 Previous mentor
   0 Notice on bulletin board
   4 Memo from personnel office
   1 Verbal request from personnel office
   2 Other, specify:_____

   Supervisor.

   Program Coordinator on site.

2. Did you volunteer to be a mentor?

   8 Yes
   0 No

3. Did the student application provide sufficient information?

   8 Yes
   0 No

4. If no, what additional information would you want to see included on the student application form?

   One mentor commented that questions should be asked concerning technical capabilities.

   I chose a student I was familiar with, I never saw the applications.

5. Did you interview the student who was placed in your laboratory before the program started?

   1 Yes
   7 No

6. If no, would an interview have been useful?

   3 Yes
   3 No

7. In your opinion, how much has the student's work in your laboratory contributed to his/her understanding of the nature of scientific research?

   8 A lot
   0 Some
   0 Not at all

8. How much did the student contribute to the research of your laboratory?

   6 A lot
   2 Some
   0 Not at all

9. How would you rate the student's performance?

   8 Excellent
   0 Fair
   0 Poor

10. Would like to participant as a mentor for the program next summer?

    7 Yes
    1 No
      If No, Why?

    Just every few years.

11. Would you want the same student in your laboratory next summer?

    7 Yes
    1 No
      If No, Why?

    Student starting college.

12. Did the work of the student influence his/her choice of

    a. courses in coming school year? 3 - Yes 1 - No 4 - Don't know
       Explain:

       Most comments were that the courses have already been set. One commented that the student changed from nuclear engineering to electrical engineering.

    b. career choice? 4 - Yes 1 - No 3 - Don't know
       Explain:

       Comments were that the work was parallel to career choices.

If you have suggestions or comments on the program, please use the space below.

PLEASE RETURN BY 14 September 1990

to: Susan Espy
Coordinator

Universal Energy Systems
4401 Dayton-Xenia Road
Dayton, OH 45432
Address

_____
Name of student apprentice

_____
Name of mentor/laboratory

_____
Date

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
APPRENTICE EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A HIGH SCHOOL STUDENT)

(A = A LOT
B = SOME
C = A LITTLE
D = NOT AT ALL)

I. How much were you exposed to each of the following during your summer apprenticeship? (Circle one letter per line.)

A	B	C	D	1.	Philosophy of research
A	B	C	D	2.	Use of scientific method to solve problems
A	B	C	D	3.	Use of experimental checks and controls
A	B	C	D	4.	Measurement techniques
A	B	C	D	5.	Design of equipment
A	B	C	D	6.	Calibration of reagents, standards, and instruments
A	B	C	D	7.	Process of design of an experiment
A	B	C	D	8.	Data analysis (with or without computer assistance)
A	B	C	D	9.	Computer programming
A	B	C	D	10.	Acquisition and use of scientific literature (books, audio visual)
A	B	C	D	11.	Identification of new questions as a consequence of scientific exploration
A	B	C	D	12.	Teamwork in scientific research
A	B	C	D	13.	Use of advanced scientific equipment
A	B	C	D	14.	Other students with similar interests and goals
A	B	C	D	15.	Scientists working in different areas of research
A	B	C	D	16.	Information on scientific careers

II. How much has your experience as an apprentice contributed to your development in each of the following? (Circle one letter per line)

A B C D 1. Working with adults

A B C D 2. Responsibility on a job

A B C D 3. Understanding of scientific principles

A B C D 4. Scientific vocabulary

A B C D 5. Ability to write a technical report

A B C D 6. Understanding of your interests and abilities

A B C D 7. Educational goal setting

A B C D 8. Insights into career opportunities in science

A B C D 9. Career goal setting

(A = A LOT
B = SOME
C = A LITTLE
D = NOT AT ALL
E = NOT AVAILABLE/
NOT RELEVANT)

III. To what extent did you benefit from the following?

A B C D E 1. Planned lectures or seminars

A B C D E 2. Explanations of work by mentor

A B C D E 3. Tours of other laboratories or installations

A B C D E 4. Informal talks with mentor

A B C D E 5. Discussions with other scientists

A B C D E 6. Interactions with other apprentices

A B C D E 7. Advice from the program coordinator

(A = STRONGLY AGREE

B = AGREE
C = DISAGREE
D = STRONGLY DISAGREE)

IV. How do you feel about your research apprentice experience?

A	B	C	D	1.	I enjoyed the experience
A	B	C	D	2.	I liked the scientific research
A	B	C	D	3.	I was satisfied with the way I spent my time
A	B	C	D	4.	I learned a lot
A	B	C	D	5.	I feel I contributed to the research results

V. Would you want to return to the same mentor next year?

o Yes o No: If No, why?

- o personality conflicts
- o lack of interest
- o want a different experience
- o want a different location

VI. What did you like most about the program?

VII. What did you like least about the program?

DO NOT SIGN

RETURN FORM TO YOUR COORDINATOR BY 14 September 1990
date

Susan Espy
Name of Coordinator

Universal Energy Systems
4401 Dayton-Xenia Rd.
Dayton, OH 45432
Address

1990 USAF/UES HIGH SCHOOL APPRENTICESHIP PROGRAM
APPRENTICE EVALUATION QUESTIONNAIRE
(TO BE COMPLETED BY A HIGH SCHOOL STUDENT)

(A = A LOT
B = SOME
C = A LITTLE
D = NOT AT ALL)

I. How much were you exposed to each of the following during your summer apprenticeship? (Circle one letter per line.)

A	B	C	D		
46	27	26	6	1.	Philosophy of research
36	35	26	8	2.	Use of scientific method to solve problems
45	23	26	11	3.	Use of experimental checks and controls
42	26	18	19	4.	Measurement techniques
38	30	24	13	5.	Design of equipment
30	20	20	35	6.	Calibration of reagents, standards, and instruments
39	31	19	44	7.	Process of design of an experiment
80	17	6	2	8.	Data analysis (with or without computer assistance)
65	17	11	13	9.	Computer programming
47	28	22	8	10.	Acquisition and use of scientific literature (books, audio visual)
34	44	18	9	11.	Identification of new questions as a consequence of scientific exploration
62	30	9	4	12.	Teamwork in scientific research
61	26	11	7	13.	Use of advanced scientific equipment
34	29	26	16	14.	Other students with similar interests and goals
51	29	17	7	15.	Scientists working in different areas of research
48	33	20	4	16.	Information on scientific careers

II. How much has your experience as an apprentice contributed to your development in each of the following? (Circle one letter per line)

A	B	C	D		
77	21	7	0	1.	Working with adults
68	27	10	0	2.	Responsibility on a job
46	34	22	3	3.	Understanding of scientific principles
57	27	16	5	4.	Scientific vocabulary
33	46	19	7	5.	Ability to write a technical report
65	30	10	0	6.	Understanding of your interests and abilities
55	33	14	3	7.	Educational goal setting
60	29	13	3	8.	Insights into career opportunities in science
51	33	19	2	9.	Career goal setting

(A = A LOT
B = SOME
C = A LITTLE
D = NOT AT ALL
E = NOT AVAILABLE/
NOT RELEVANT)

III. To what extent did you benefit from the following?

A	B	C	D	E		
15	19	21	2	48	1.	Planned lectures or seminars
73	22	5	4	1	2.	Explanations of work by mentor
27	28	22	5	23	3.	Tours of other laboratories or installations
73	19	7	5	1	4.	Informal talks with mentor
59	27	14	2	3	5.	Discussions with other scientists
36	19	22	10	18	6.	Interactions with other apprentices
16	22	25	18	24	7.	Advice from the program coordinator

(A = STRONGLY AGREE
B = AGREE
C = DISAGREE
D = STRONGLY DISAGREE)

A	B	C	D		
				IV.	How do you feel about your research apprentice experience?
79	22	4	0	1.	I enjoyed the experience
59	37	3	6	2.	I liked the scientific research
51	41	10	3	3.	I was satisfied with the way I spent my time
73	25	6	1	4.	I learned a lot
55	37	5	7	5.	I feel I contributed to the research results

V. Would you want to return to the same mentor next year?

72 Yes 31 No: If No, why?

1	personality conflicts
5	lack of interest
23	want a different experience
10	want a different location

VI. What did you like most about the program?

35 of the students thought that the mentor and the various people in the laboratory was what they liked the most about the program. They commented that they were treated as adults and not as high school students, that what they thought or accomplished was important. 29 of the students liked the exposure to a work atmosphere. The students were very thankful to have the opportunity to work beside scientist and engineers doing real research. Another comment was that the equipment, laboratories, and computers are what 19 of the students liked the most. Eleven of the students liked the project that they were assigned to, and the learning experience that they had. A few students expressed that before they received the position that they had not decided on a career, but 8 students have now due to the program. Five of the students liked the different employment opportunities that are available, while 2 of the students liked learning more about the Air Force and the opportunities that they have available.

VII. What did you like least about the program?

The majority of what the students liked least was that the program was not long enough. The 12 responses indicated that the program should be lengthened to 10 to 12 weeks. Eleven of the students commented at they were not keep busy. The mentors did not either have the time to spend with them, or the students finished the projects that the mentors had assigned. Six of the students disliked writing a final report at the end of the summer. While another six students thought the pay should be higher considering the type of work they were doing. Five of the students commented that they did not do the project that was originally discussed once they got there. Another five students least liked the timecards and there schedule, also the delay in getting their paychecks. Four students responded that their mentors were TDY and was not available for most of the summer. Four other students commented that they did not get along with the people in labs, that they were treated like "gofers" and doing errands, and office work. Another 4 students disliked the project they were doing, some of the comments were that they did not think it was real research but "busy work". Other comments consisted of no sick or holiday pay, lack of information about UES, no positions available for college students, getting up early, lack of air conditioning, and even that the water tasted funny.

DO NOT SIGN

RETURN FORM TO YOUR COORDINATOR BY 14 September 1990
date

Susan Espy
Name of Coordinator

Universal Energy Systems
4401 Dayton-Xenia Rd.
Dayton, OH 45432
Address
2361s

LIST OF PARTICIPANTS FINAL REPORTS

RESEARCH REPORTS

1990 HIGH SCHOOL APPRENTICESHIP PROGRAM

Technical Report Number	Title	Participant
VOLUME I		
Aero Propulsion Laboratory		
1	Flash Plate Evaporator	Matthew Bold
2	Frozen Start Up	Hee Sun Choung
3	Nonaqueous Battery Research	Katharine Day
4	Setup Tecplot	Chris Hatch
5	Flash Plate Evaporator	Chet Nieter
6	Final Report to UES	Jennifer Pollock
7	Frozen Start Up	Carol Rogers
Armament Laboratory		
8	Wind Velocimeters for Calculating Ballistic Trajectories	Steven Bryan
9	Star Availability for Sensor - Specific Evaluation (S.A.S.S.E.)	Tonya Cook
10	Development of a Customized Database System for the Distribution of EPIC Hydrocode Software	Heather Cox
11	Synthesis and Characterization of 3-Picrylamino-1,2,4-Triazole	Kathryn Deibler
12	Neural Target Identification	Chris Ellis
13	Space Debris Analysis	Dana Farver
14	Enhancement and Integration of Post Process Utilities for the EPIC Hydrocodes	Kenneth Gage
15	Design of In-House Radar Control and Data Acquisition Systems	Reid Harrison
16	1990 HSAP Final Event Summary	Derek Holland

35	Program Final Report	Jason Scott
36	Real-Time Radiography Ray Tracing	Gerald Turner
Astronautics Laboratory		
37	The Summer in Review	Alisha Conrow
38	Synthesis of Two Cage Compounds	Debra Meyer
39	Fundamental Rocket Exhaust Measurements	John Moro
40	Analytic Predictions of Hydroxy-terminated Polybutadiene (HTPB) Modulus using Random Iterative Discrete Node Algorithm (RIDNA)	Lloyd Neurauter
41	Liquid Engine Computer Codes	Joseph Padilla
42	Determination of Active Surface Area and Density of Carbons	Melanie Pyle
43	No Report Submitted	Thomas Quinn
44	High School Apprenticeship Program Final Report	Tracy Reed
45	1990 Final Report	Benjamin Sommers
46	No Report Submitted	Stephanie VanMeter
47	A Comparison of Electric Propulsion Orbit Transfer Methods	Rebecca Weston
48	No Report Submitted	David Youmans
Avionics Laboratory		
49	Ada Compiler Evaluation Capability Testing Utility (ACEC)	Brian Barclay
50	Pattern Based Machine Learning	Mark Boeke
51	Pattern Based Machine Learning: A Comparison of ADA Function Decomposer Versions	Michael Chabinyc
52	Computer Simulation of SDI	David Collins
53	Final Report Summer 1990	Austin Flack
54	No Report Submitted	Jerard Wilson

Engineering and Services Center

55	Surface Catalyzed Reactions of Vapor Phase Hydrazine	Jennifer Brewer
56	Sims. Billeting	Philip Dorsch
57	Alternate Pavement Materials	David Eshleman
58	Apprenticeship Final Report	Richard Hartzer
59	A Neural Network Edge Enhancer	Thor Johnson
60	Summer Research	Tracy Lamb
61	Final Report	Brent Miller
62	Effects of Compaction on Unsaturated Sand	Debra Piechowiak
63	Design and Testing of an In-house Electronic Publishing System for National Laboratories	Jonathan Protz
64	Summer Apprenticeship at HQ AFESC/DEC	Julie Scruggs
65	No Report Submitted	Michael Stone
66	The Effects of High Pressure Tires	Amy Thomas
67	The Effects of High Strain Rates on Sand	Michael Thompson
68	Centrifuge Modeling of Explosive Induced Stress Waves in Unsaturated Sand	Jeffrey Ward
69	CD-ROM Compact Disc Read Only Memory	Robin Woodworth

VOLUME III
Electronic Technology Laboratory

70	Final Report	Matthew Brewer
71	The Making of a Transistor	Matt Elwood
72	Imagepro User Guide	Shelly Knupp
73	Computer-Aided Design (CAD) Area	Christopher O'Dell
74	Electron Beam Lithography	Suzette Yu

Flight Dynamics Laboratory

75	High School Apprenticeship Program Final Report	Jean Ay
76	Project "Environmental Reliability": The Analysis of Printed Circuit boards	Matthew Becker
77	High Speed Performance Computer Resources Team	Wendy Choate
78	No Report Submitted	Andrea Dean
79	Leading Edge Heat Exchanger	Rachael Lyon
80	Final Report for Cathie Moore	Cathie Moore
81	Project Instrumentation	Roderick Morgan
82	ENTRAN Manual	Stanley Wall
83	Final Report	Douglas Wickert

Geophysics Laboratory

84	Determining Tropical Storm Direction of Movement Using SSM/I Brightness Temperature Data	Stephen Britten
85	Auroral Boundaries	Weihaw Chuang
86	Mesoscale Modeling	Christopher Guild
87	No Report Submitted	Jason Klingensmith
88	Solar Terrestrial Interactions	Galen McKinley
89	Ionospheric Effects	Jeffrey Sayasane
90	Final Report	Paul Swietek

Materials Laboratory

91	Fatigue of Composites	Jennifer Walker

Occupational and Environmental Health Laboratory

92	Automated Heat Stress Measurements	Gary New
93	Compilation of Hazardous Waste Surveys	Andrea Dean (Perez)
94	Automation of Water Analysis	Michael Smid

Rome Air Development Center

95	Pre-Commissioning and Capabilities of the Workhorse Scatterometer: A Final Report	Daniel Abbis
96	No Report Submitted	Mark Anania
97	Radar Range Equation and Radar Design and Simulation	Bridget Bordiuk
98	No Report Submitted	Todd Gleason
99	Cartographic Applications	Christopher Hailes
100	Application Software Development for use on Directory Specific Network	Edward Holmes
101	Various Projects in Data Analysis of Surveillance Systems	Kimberly King
102	Network Processing Element Test and Evaluation	Kathryn Lee
103	Gemacs Version 5.0 Modifications and Applications	Jason Lenio
104	Activities at RADC Photonics Lab	Kevin Olson
105	Overview of Neural Networks	David Petrillo
106	Surface Analysis	Thomas Potter
107	Software Inventory Control System Database	Daniel Russell
108	Artificial Neural Networks	Philip Schremmer
109	Local Area Networks	Eric Shaw

VOLUME IV
School of Aerospace Medicine

110	No Report Submitted	Anthony Barnes
111	Final Report	Whitney Brandt
112	Preliminary Testing of an Inert Gas Concentrator Using Carbon Molecular Sieve	Deann Cooper
113	Affects of Anti-G Straining Maneuvers on Blood Pressures in Man; Affects of +Gz on the Cardiovascular System of Baboons	Matthew Felder

114	Apolipoprotein Comparison Study and CAD Prediction Study	Christopher Hudson
115	High School Apprenticeship Program Final Report	Soyna Longbotham
116	Determination of Optimum Growth and Strain Facilities for Diazotyrosine Production	Brian McBurnett
117	Serum Factor - Induced Expression of the C-FOS Gene in NIH 3T3 Cells	Heather Neville
118	Biological Rhythms Research	Lori Olenick
119	Report on File with UES & SAM	Joanna Saucedo
120	Medical Entomology Activities	Wendy Shields
121	Establishing High and Low Rate Operant Behavior in Rats	Brent Strawn
122	UES Report	John Taboada

Weapons Laboratory

123	Phase Conjugation and Beam Coupling	David Cochrell
124	Final Report	Paul Hillman
125	A Study in C	David Knapp
126	Final Report of Summer Mentor	Aaron Laing
127	Statistical Analysis of Cone Penetrometer Data	Kerim Martinez
128	No Report Submitted	Ryan McAlhaney
129	Microwave Susceptibility Testing of Micro-Circuitry	Margaret Morecock
130	Construction of a Delay Circuit for Data Acquisition Coordination	Philip Ortiz
131	Contour Plots	Brian Rizzoli
132	Wide Bandwidth Crosslink Register Technical Report	Chris Stoltenberg

FINAL REPORTS

SCHOOL OF AEROSPACE MEDICINE

Anthony Barnes

Final Report Number 110

No Report Submitted

High School Apprenticeship Program

Whitney Brandt
Dr. Sarah A. Nunneley

17 AUG 90

I would like to sincerely thank all those who made this summer possible. With there help I had a very enjoyable and educational summer.

Dr. Sarah Nunneley
Maj. Sue Bomalaski
Dr. Melchor Antunano
Mr. John Garza
Mr. Tai Chen
Dr. Steve Constable
Dr. Loren Myhre

Even though I participated in the Apprenticeship Program last summer, I still learned a great deal. While I was here I participated in many projects. My major focus was on the temperature experiment, but I also spent a lot of time working on a study of a Heat Stress Monitor. This monitor consisted of a heart rate monitor and a temperature sensor. The monitor is supposed to signal the wearer when to stop working. We conducted many experiments trying to determine the internal mechanism of this monitor. We also tried to determine under what conditions the monitor will warn the subject to stop working. Since the company would not specify whether or not the temperature sensor was reading skin temperature or core temperature, we had to use our own judgment as to its ability. Throughout the experimental process, a varied amount of results were found. Some of the time the sensor would read a temperature similar to that of skin, but other times it would be closer to rectal temperature. There were also times when it would not follow either one. After testing this monitor in various environments and under several different conditions, we were still unsure as to what the sensor was reading.

While I was here, I also helped with data analysis. I worked on data entry and calculations for several projects. Also, I learned how to operate a Thermovision infrared camera. We used this camera to measure the temperature differences between the different areas of the body of a subject wearing the Chemical Defense Ensemble before and after exercise.

Besides the many things I was involved in, I was able to attend many interesting lectures and meet many different people. I was exposed to the various career fields available in science, mathematics, and engineering. I really enjoyed my eight weeks here and would recommend it to everyone.

Introduction

Physiologists using human subjects would like to find a simple, reliable, and accurate way to measure core temperature other than using a rectal probe. Telemetry systems which transmit temperature were invented in the early 1970's, but these sensors were too large for human use (4). With the development of miniaturization, ingestible "radio pills" were manufactured and used in 5 studies. However, these "pills" lacked accuracy and reliability (1,2,3).

Human Technologies Inc. manufactures a new type of temperature transmitting sensor that is reported to be very accurate, reliable, and easy to use. The Cortemp Disposable Temperature Sensor was developed by The Applied Physics Laboratory of The John Hopkins University using a grant from NASA. This temperature sensor (pill) has a range from 10 to 50°C and functions from a silver-oxide battery which is operated by a magnetic power switch. The patient (subject) removes the magnet to turn on the pill, then swallows it. An antenna shaped like a bandolier is worn around the chest to transmit the signal from the pill to the ambulatory recorder. The recorder then displays the temperature and stores it in memory at specified intervals in the range of 30 seconds to 60 minutes.

Methods

Calibration Check

For this experiment USAFSAM purchased fifteen Cortemp Disposable Temperature Sensors, and borrowed an antenna and ambulatory recorder from the vendor. The pills were calibrated in a small laboratory. Each of the pills was calibrated in a large Styrofoam container placed on top of a wooden counter to prevent interference. There were no computers or video equipment within the suggested distance of six plus feet. Also, the Ambulatory recorder was located more than four inches away from the antenna to prevent the "no read" display. The temperature pill was

calibrated against a mercury-in-glass thermometer. The thermometer was clamped with its bulb in the center of the Styrofoam container by a ringstand. String was tied to the pill so that it could be suspended adjacent to the thermometer bulb. To insure that the water temperature was equal throughout the container, the water was hand stirred. The water in the container cooled at a rate of .1°C per two minutes. Before beginning calibration, the manufacturer's calibration information was entered into the recorder so that it could automatically correct for the calibration difference. To calibrate the pill, the water was stabilized at a constant temperature at approximately 32°C. After twenty-five pill readings at this temperature, the water was raised to approximately 42°C, where another twenty-five readings were taken. After every pill reading, the temperature indicated by the mercury-in-glass thermometer was also recorded.

Experiments

In the first three experiments, the subjects swallowed the sensor a few minutes before beginning data collection. The antenna was placed next to the skin over the various other measuring devices (skin thermistors, heart rate monitor). The subject dressed in the Chemical Defense Ensemble (CDE),and the cable was fed through the clothes and attached to the recorder which was taped to the hand rail of the treadmill. The subject walked on a treadmill at 3.5 mph/7.5% with the ambient air temperature at 27-29°C. Once the subject's rectal temperature (Tre) reached 39.0°C exercise was terminated. The subject then removed the suit and cooled down while drinking water.

The second set of experiments was done in a similar manner. In these experiments three subjects walked on the treadmill at the same setting as above with the air temperature at 33°C, but while wearing light clothing (tee-shirt and shorts). Also, during these tests the subject was

given the sensor ahead of time and asked to swallow the pill at least three hours prior to beginning the experiment.

In the final group of experiments, the subjects wore light clothing with the ambient air temperature at 33°C. However, the subject was asked to walk for an hour then jog for a few minutes. Also as the subjects in group two, they swallowed the sensor at least three hours before starting the experiment, and they refrained from drinking water until the pill temperature was stable.

Long Duration

Besides the three different types of thermal studies, the pill was used in a separate experiment to determine its capability in a work/rest environment. First, the sensor was placed alongside a rectal probe in a fingercot. The subject then walked on a treadmill at a high workload, outside in light clothing. Because Tre did not rise quickly enough the subject put on the CDE and mask. The following day, the sensor was swallowed and the subjects core (pill) and Tre temperatures were monitored. The subject walked on the treadmill in light clothing for one hour. The ambient air temperature was 33°C and the treadmill was set on 3.5 mph/7.5% grade. After walking, the subject cooled down while drinking water. After two hours of rest the subject resumed exercise on a bicycle ergometer. When this one hour of exercise was finished, the subject cooled down without water.

Results

During the calibration process many problems were evident. The temperature readings during calibration of the first two pills were very erratic. They started out at approximately 15°C, when the water temperature as read by the thermometer was at 33°C. After climbing to about 20°C, in about ten minutes, the readings began to jump around, going from 37 to 33 and back up to 41°C. When they finally began to settle

down, all of the readings were at least 2.0°C higher or lower than the actual water temperature. Another problem was determining if the pill was on or off. Just by moving the recorder the display would change. In one case the recorder showed that the pill was "on" and gave a valid temperature reading, even when there was no pill in a close proximity. Also, there were many "weak signal" and "no read" readings. But, when the system was checked, it was found that an antenna pin was defective and the two pills were not transmitting properly. After the antenna was fixed, the procedure began to run smoothly.

After calibration, there were eleven usable temperature pills remaining. The two mentioned above were discarded because of their malfunctions, and a second two were unusable because when they were rechecked after calibration, they were not working properly. Ten of the remaining eleven were used in various thermal experiments.

Figure 1 displays calibration results of the ten temperature pills used later by the human subjects. The solid black line is the line of identity. Each of the calibrated sensors read at least .13°C lower than the mercury-in-glass thermometer. The first pill was 1.0°C low, so it was discarded and not used in any experiments.

Once each experiment was complete the data was entered into a Macintosh Computer spreadsheet. To compensate for the difference between the mercury-in-glass thermometer and the sensor, a corrected pill value was calculated (pill*). This value is the actual pill reading plus the calibration difference determined in our laboratory.

During the first group of three studies, all the pills seemed to react in a similar manner (Figure 2). Each of the subjects exercised for the same amount of time. Once they stopped, they removed the CDE and began drinking water. In all three cases the corrected pill values were very close to or the same as Tre. Also, in these experiments the water caused

a drastic decrease in the temperature of the pill.

In the second set of experiments, the pills had a variety of results (Figure 3). In all three subjects the corrected pill value followed closely to Tre throughout exercise then diverged as the subject stopped working. Even though subject one walked longer than the others, his pill results were very similar to subject two. Both of their pill* values were higher than Tre. Also, the readings of their pills produced a lot of noise (bad readings) towards the end of the experiment when they drank water. This did not occur in subject three.

In the final group of subjects, there was also a wide range of results (Figure 4). All three subjects walked for the same amount of time, and they all were not given water until a specific time. In subjects one and three the pill* value was higher than Tre. However, the pills swallowed by subjects one and two reacted the same way at the end of the experiment. Both subjects had erroneous readings during the running portion of the experiment and while drinking water as did all the subjects.

During the long duration experiment with the one subject, the pill reacted differently from many of the others. In this experiment the actual pill value was higher than Tre. It remained above or the same as Tre throughout the entire experiment. However, the temperature of the pill was still affected by the ingestion of water.

Discussion

Throughout the various calibrations and experiments, many ideas and questions were posed. Over the duration of these experiments, we tested the effects of many variables on the pill's ability to function. The pill was tested while the subject was wearing both heavy and light clothing. This was done to determine clothing effects on the antenna's transmitting ability. Also, the pill was tested in a work/rest environment to illustrate the effects of a quick increase in core temperature on the sensor.

The major question was how to determine if and when the temperature pill leaves the stomach and enters the intestine. Many articles suggest that the sensor will be less susceptible to drastic temperature change while drinking water if it is out of the stomach. However, when the subjects were asked to swallow the pill at least three hours before beginning the experiment, the sensor temperature dropped .2-.3°C within three minutes after drinking the water. Since each individual is different, determining gastric emptying time is difficult. Emptying rate varies from person to person. Since this is a major factor the sensors measuring ability, it poses a major question regarding the reliability of the pills due to its location.

Conclusions

The following points summarize the problems encountered while using the Cortemp system.

1. Difficulties with pills in lab-The temperature pills which we received from Human Technologies Inc. were not completely reliable. The first two pills that were opened and used were found to be defective. Also, the antenna that we were furnished had a malfunctioning cable pin.
2. Offset-After the initial problems were fixed, each of the calibrated pills had an offset. This offset ranged from .13-1.0°C. In most cases the temperature difference was approximately .2-.4°C.
3. Noise-During the calibration process, many of the pills had erroneous readings, especially the first two. Noise was also present during the human experiments. However, it usually did not occur until the subject was almost through with exercise, or while they were drinking water.
4. Lockup-There were three cases of lockup during the duration of

all the experiments and calibration. Lockup is when the recorder is acting normally, and all of a sudden it stops reading. There is no way to get out of lockup without turning off the recorder and starting again. It was believed that this occurred because of a low battery. However, it occurred when a new battery had been installed.

5. Delayed Response Relative to Tre-Most studies suggest that esophageal temperature (Tes) is more responsive than Tre. We had hoped that the pill temperature would be similar to Tes because of its location in the gastrointestinal tract. However, in most of our experiments the pill temperature lagged behind Tre.

6. Battery Life of Sensor-During these experiments questions arose about the battery life of the pill. The Cortemp brochure specifies that the sensor has 100 hours of operating time. During the calibration process the pills were turned on, calibrated, and then turned off. However, during the first four pill calibration the off/on method was questionable. But, when the pills were tried again, a two days later, they were not functioning. This indicates that the pills battery had worn down. However, the manufacturers suggest that the pill will operate correctly for up to ten days.

In conclusion, it was found that the Cortemp Disposable Temperature Sensor would not be applicable in a situation that requires the sensor as the only form of measurement. There was too much variability between each individual pill. You would be unable to predict the accuracy and dependability of a pill without first calibrating it. In the field there would be only time for the subject to swallow the pill and begin recording. The investigator would not know, without some other measuring device, whether or not the reading was correct.

References

1. Ackles, K.N. Operational measurement of divers' core temperature. Defence and Civil Institute of Environmental Medicine. Technical Report No. 76-x-23, 1976.

2. Gibson, T.M., P.J. Redman, and A.J. Belyavin. Prediction of oesophageal temperatures from core temperatures measured at other sites in man. Royal Air Force Institute of Aviation Medicine. Report No. 596, 1981.

3. Higenbottam, C., and R.M. Wellicome. Expandable radio pill system for measurement of core temperature in pilots. Royal Air Force Institute of Aviation Medicine. Report No. 580, 1979.

4. Riley, J.L. Frequency-to-voltage converter for recording animal temperature by radiotelemetry. J. Appl. Physiol. 30:890-892, 1971.

Figure 1. This is a comparison between a mercury-in-glass thermometer and the Cortemp Disposable Temperature Sensor. The solid black line is the line of identity. Each of the pills was calibrated in a Styrofoam container at a constant temperature of 32°C and 42°C. This is an enlarged version of the area for human core temperature.

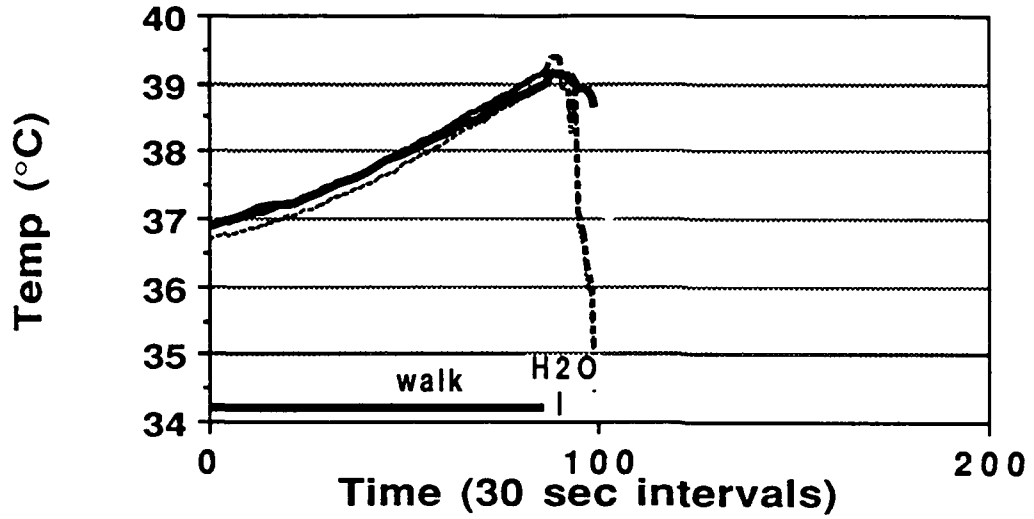
Figure 2. Experiment group one. Subjects were wearing the CDE while exercising on a treadmill set at 3.5 mph/7.5% grade. The ambient air temperature was from 27-29°C. The subjects swallowed the sensor 2-5 minutes before beginning exercise. As soon as exercise was terminated, the subject removed the CDE and cooled down while drinking water. Tre is represented by the thick solid line (━), the actual pill value is the thin dotted line (....), and the corrected pill value is the thick dashed line (╍╍).

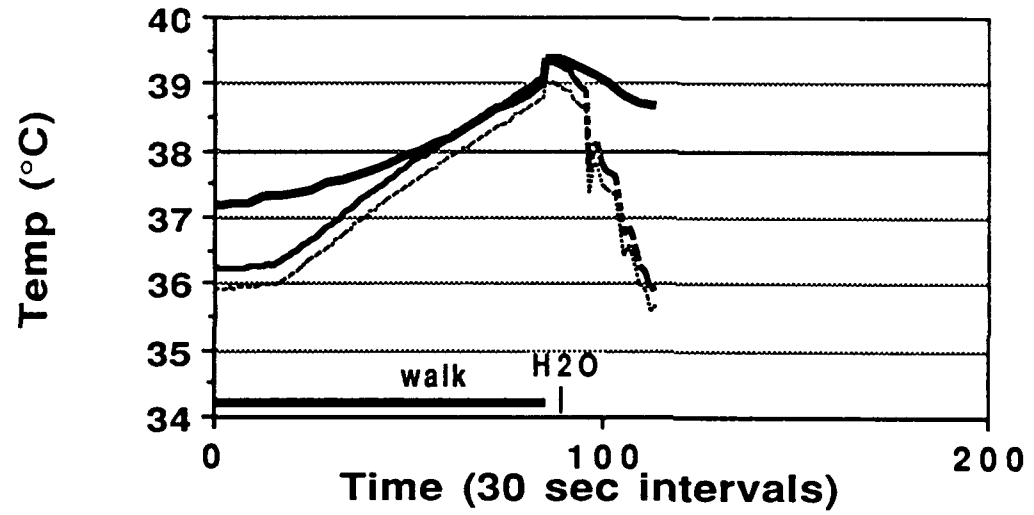
Figure 3. Experiment group two. In these experiments a group of three subjects, wearing light clothing, walked on a treadmill at 3.5 mph/7.5% with an ambient air temperature of 33°C. These subjects swallowed the pill three hours before beginning the experiment, and after stopping work, they restrained from drinking water until the sensor temperature was stable. The symbols are the same as Figure 2.

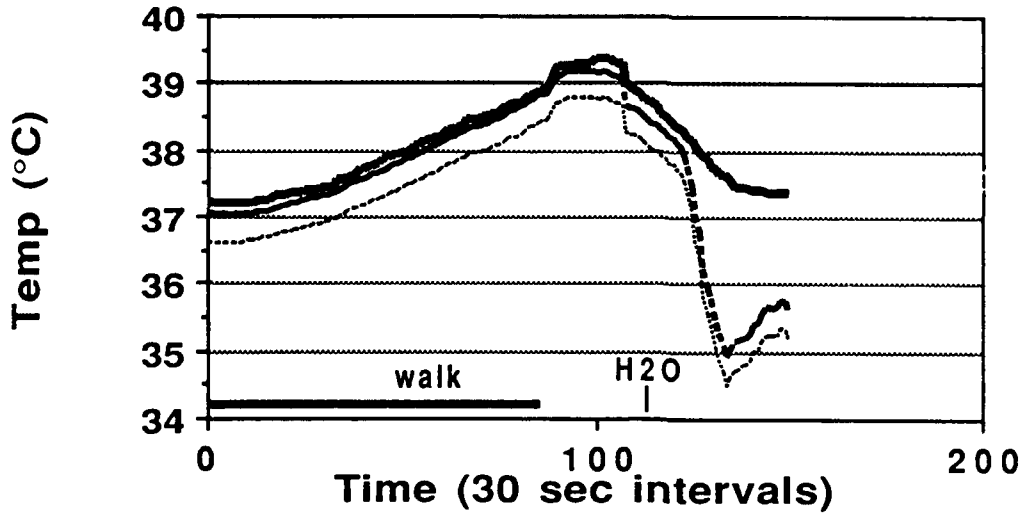
Figure 4. Experiment group three. The subjects in these experiments wore light clothing and walked on a treadmill at 3.5 mph/7.5% with an ambient air temperature of 33°C. After one hour of walking, the subject jogged for 2-3 minutes. The subject swallowed the sensor three hours before beginning, and refrained from drinking water after exercise. The symbols are the same as Figure 2.

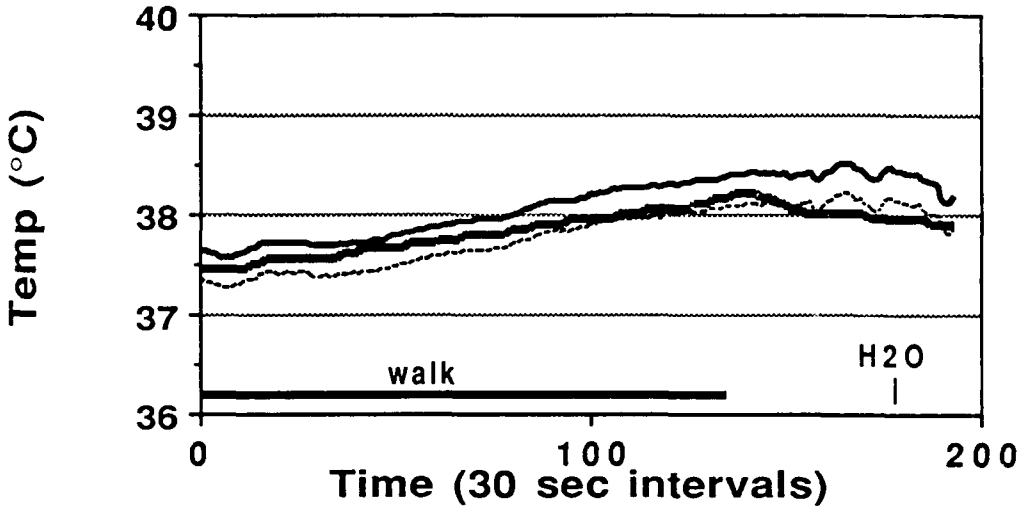
Figure 5. This is an enlarged version of Figure 4. The time scale has been changed to allow a better view of the running portion of this experiment. It makes the pill variability more evident.

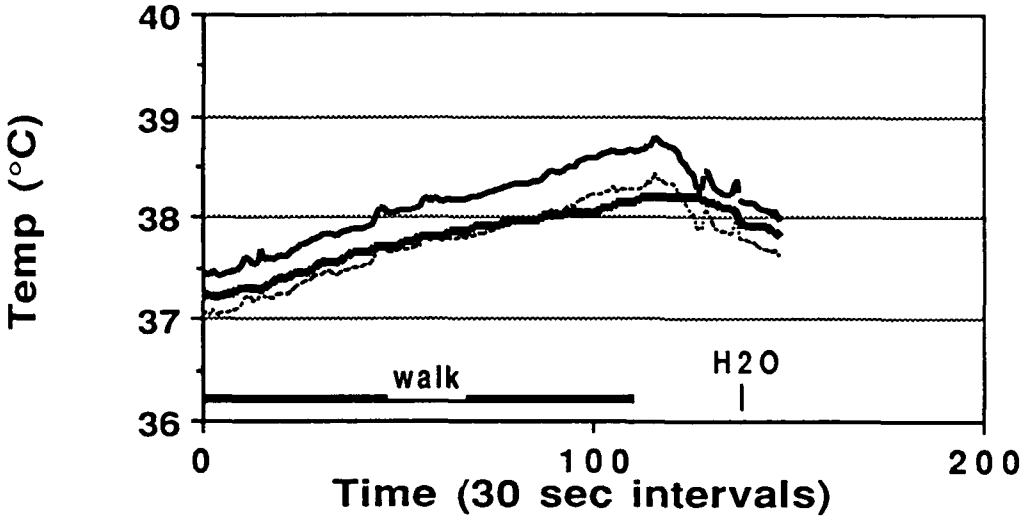
Pill Calibration
Temp (pill, °C)
Temp (mercury, °C)
38.0
37.5
37.0
36.5
36.0
36.0
36.5
37.0
37.5
38.0
pill #1
pill #2
pill #3
pill #4
pill #5
pill #6
pill #7
pill #8
pill #9
pill #10

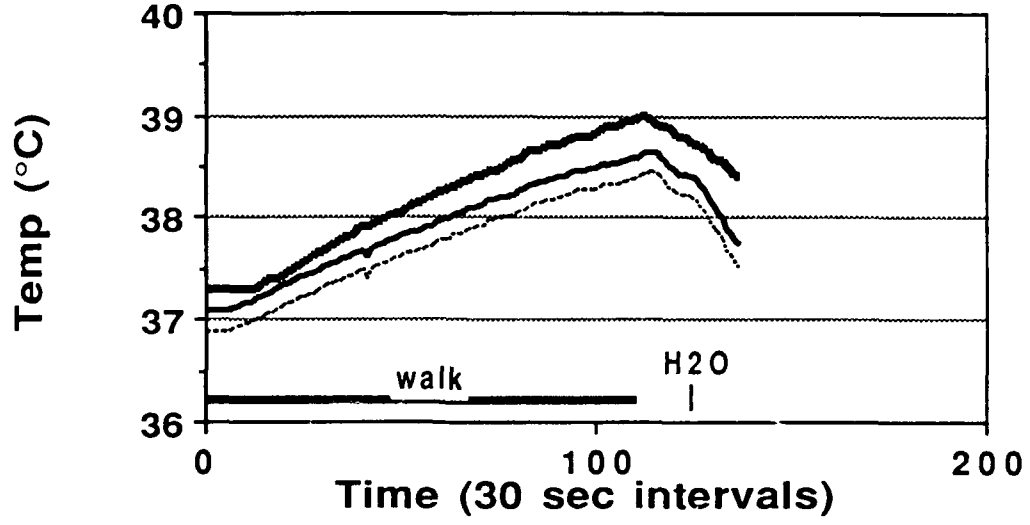

Temp (°C)
40
39
38
37
36
35
34
walk
H2O
0
100
200
Time (30 sec intervals)

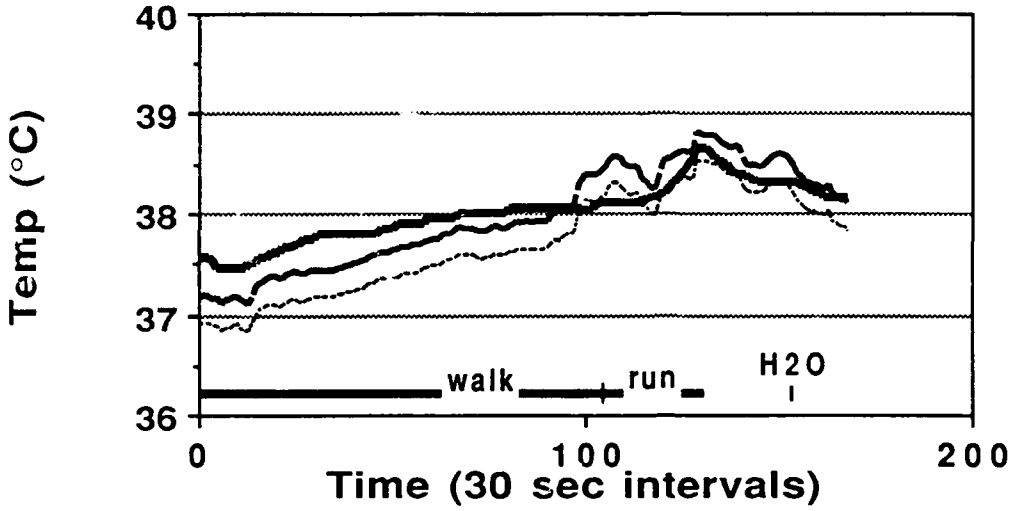

Temp (°C)
40
39
38
37
36
35
34
walk
H2O
0
100
200
Time (30 sec intervals)

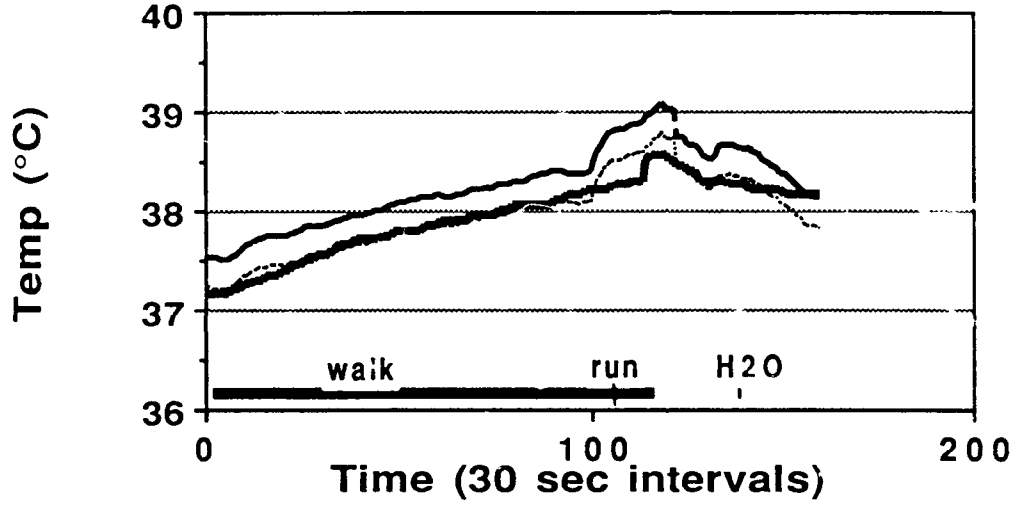

Temp (°C)
40
39
38
37
36
35
34
walk
H2O
0
100
200
Time (30 sec intervals)

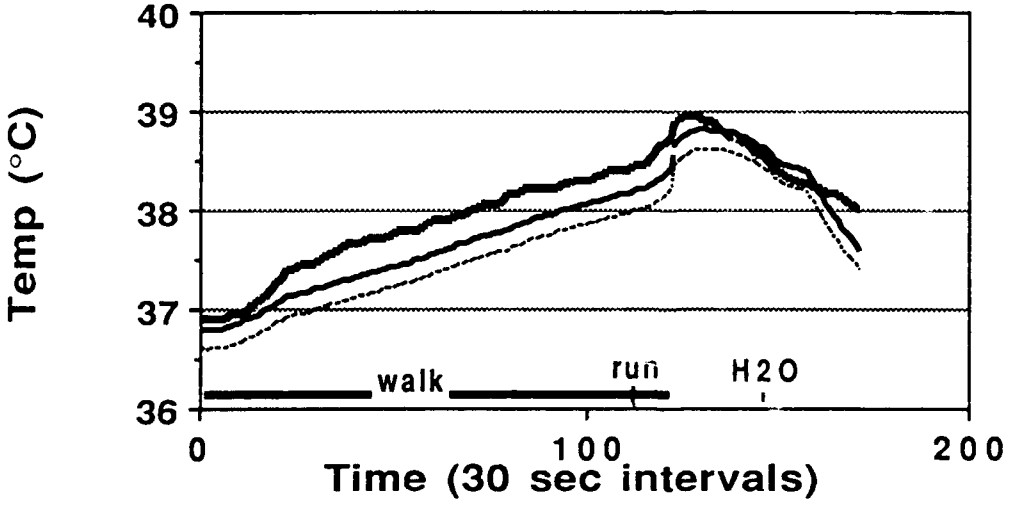

40
39
38
37
36
Temp (°C)
walk
H2O
0
100
200
Time (30 sec intervals)

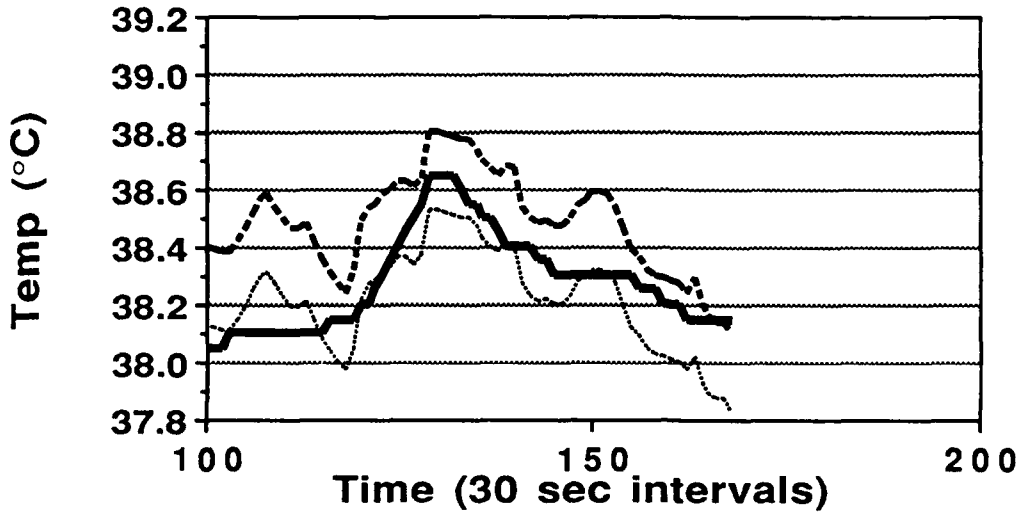

40
39
38
37
36
Temp (°C)
walk
H2O
0
100
200
Time (30 sec intervals)


40
39
38
37
36
Temp (°C)
walk
H2O
0
100
200
Time (30 sec intervals)


40
39
38
37
36
Temp (°C)
walk
run
H2O
0
100
200
Time (30 sec intervals)


40
39
38
37
36
Temp (°C)
walk
run
H2O
0
100
200
Time (30 sec intervals)


40
39
38
37
36
Temp (°C)
walk
run
H2O
0
100
200
Time (30 sec intervals)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39.0
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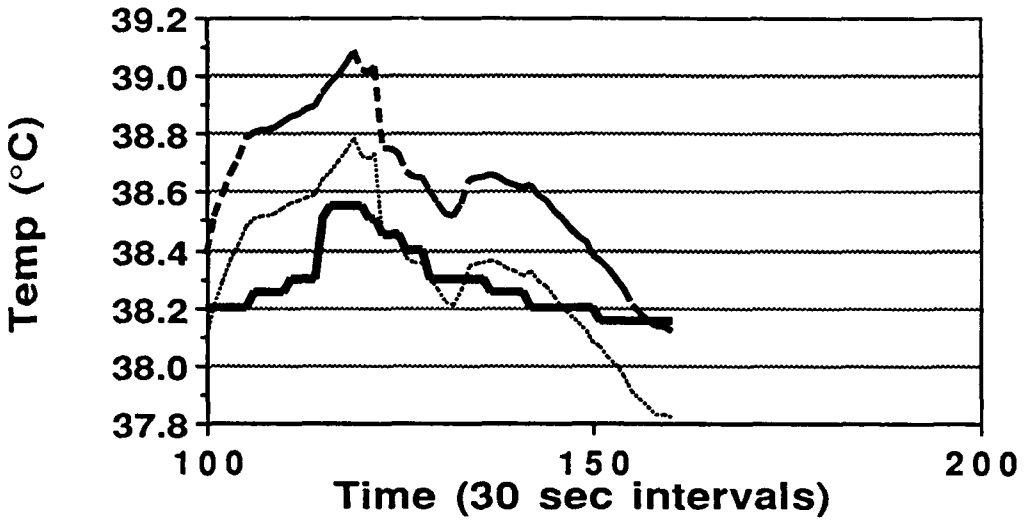
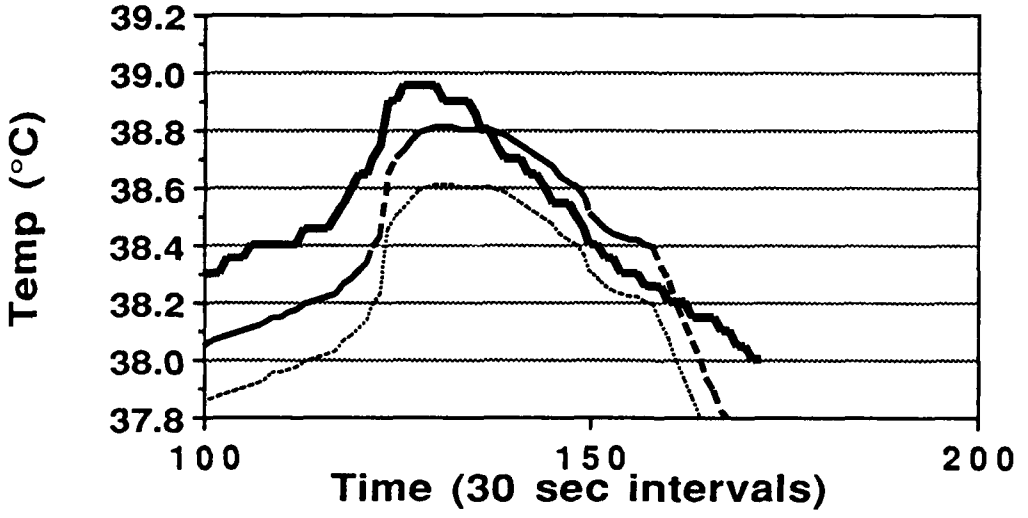
38.6
38.4
38.2
38.0
37.8
Temp (°C)
100
150
200
Time (30 sec intervals)


39.2
39.0
38.8
38.6
38.4
38.2
38.0
37.8
Temp (°C)
100
150
200
Time (30 sec intervals)


39.2
39.0
38.8
38.6
38.4
38.2
38.0
37.8
Temp (°C)
100
150
200
Time (30 sec intervals)

24 August 1990

PRELIMINARY TESTING OF AN INERT GAS CONCENTRATOR USING CARBON MOLECULAR SIEVE

DEANN COOPER

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

HIGH SCHOOL APPRENTICESHIP PROGRAM

USAF SCHOOL OF AEROSPACE MEDICINE

CREW TECHNOLOGY DIVISION

BROOKS AIR FORCE BASE, TEXAS 78235-5301

ACKNOWLEDGMENTS

I wish to acknowledge Maj George W. Miller, Dr Kenneth G. Ikels, Mr Clarence Theis, Aaron Shakocious, and Gina Rios.

I. SUMMARY

One of the techniques in adsorption technology is Pressure Swing Adsorption (PSA). PSA is a gas separation process which generally uses a molecular sieve adsorbent. The process involves the cyclic pressurization and depressurization of the adsorbent with the feed gas. The component of the feed gas which is not preferentially adsorbed is extracted as the product gas. The product gas from an air fed PSA unit may be an inert gas (gas composed of nitrogen and argon) or an oxygen enriched gas.

An experimental PSA apparatus using Takeda 3A carbon molecular sieve was constructed with the intent to extract a product gas of $\leq$ 9% oxygen. The inert gas generated by a system of this type may be used to blanket aircraft fuel tanks. If successful, this method will help in reducing possible explosions and fires. Other systems which use 4A zeolite molecular sieve and permeable membranes have also shown a capability of removing oxygen from air.

The resulting data were analyzed and can be used as a reference for further exploration in this area. With a product flow of 400 ACCM, an inlet pressure of 60 psia, and a cycle time of 15 seconds, the lowest oxygen content observed was 11.8 %. Generally, it was found that higher inlet pressures produced a higher percentage of inert gas.

This experiment is just one of the many steps in the on-going research and it is recommended that more work be done in this area.

II. INTRODUCTION

Since W. W. II aircraft fuel tank explosions have become an increasing concern. It is said that in the Vietnam conflict roughly 50 percent of the aircraft losses were due to fire or explosion.

Without a fuel tank inerting system the mixture of fuel vapors and air in the fuel tank vapor space (ullage) is susceptible to ignition by combat damage, equipment malfunction, lightning, and electrostatic discharges.

Fuel tank inerting consists of reducing the oxygen concentration in the ullage to a level which will not support combustion. It has been determined that a level of 9% or less oxygen will not support combustion.(6)

Some previous attempts to solve this problem have involved the use of liquid nitrogen (LN_2) and explosion suppressant foam. The LN_2 system provides fuel tank fire protection by supplying sufficient nitrogen from storage bottles to maintain an inert ullage. Explosion suppressant foam prevents excessive overpressures by localizing any in-tank fires to small compartments.

The liquid nitrogen and suppressant foam systems have drawbacks. The LN_2 system provides effective fuel tank fire protection, but has the disadvantage of requiring a supply of cryogenic nitrogen nearly every time the airplane is refueled. Additionally, there are a limited number of bases which can provide this service. This limitation poses a serious logistics problem. The drawbacks of the suppressant foam were high weight, high installation and maintenance costs, susceptibility to electrostatic problems, and premature decomposition.

Presently, three techniques for generation of an inert gas from air are being evaluated. These three techniques are:

1. Hollow fiber permeable membranes
2. PSA using 4A zeolite molecular sieve.
3. PSA using a carbon molecular sieve

Permeable membranes are typically formed into fiber bundles. The ends of the fiber bundles are gathered and placed together in epoxy tube sheets. After the epoxy cures, the ends are shaved to open the ends of the hollow fibers. These bundles are then placed into an outer case.

Bleed air from the engine is passed through the center of the hollow fibers. Oxygen diffuses through the wall of the fibers faster than nitrogen. Oxygen collects on the other side of the fiber wall at low pressure and is vented overboard. An inert gas composed of mostly nitrogen is then collected at the other end of the tube sheet. The principal control devices for this system are a flow control orifice and an inlet pressure regulator.

Zeolite molecular sieve 4A may be used in conjunction with the PSA process to produce an inert gas. Pressurized air is passed through the beds of adsorbent where oxygen is adsorbed through the pores in the sieve. This separation is diffusion-induced because oxygen diffuses more readily into the molecular sieve than does nitrogen. Hence, the gas phase concentrates nitrogen and argon. This inert gas then flows out the product end of the system and is collected.

The PSA process using carbon molecular sieve (CMS) is very similar to the zeolite molecular sieve process. Both separate oxygen from nitrogen based on the rate of diffusion. Oxygen diffuses more quickly

into the CMS than does nitrogen. Hence, nitrogen and argon concentrate in the gas phase. PSA research data using CMS is relatively scarce.

The only disadvantages to the permeable membrane system are the weight and expense, otherwise it is a relatively simple system. One drawback with the zeolite molecular sieve is that it adsorbs water strongly. Water will displace the oxygen, nitrogen, or argon, and consequently result in a less effective separation of oxygen and nitrogen. Although the PSA systems require little maintenance, they are large and heavy. The PSA process using CMS has not been evaluated adequately to thoroughly define its strengths and weaknesses.

When research was begun for this experiment there were three main objectives in mind.

1. To evaluate the performance of a PSA apparatus using 3A CMS based on the oxygen concentration of the product gas.
2. To determine the effects of the inlet pressures, cycle time, and product flow on the oxygen concentration.
3. To determine the recovery and productivity of the apparatus.

III. EXPERIMENTAL

The experimental PSA apparatus was comprised of two cylindrical beds with an outer diameter of 1.5 in. (3.81 cm) and a length of 10 in. (25.4 cm). A short conical section of the bed at the product end was 1.75 in. (4.45 cm) in length and had a diameter of 1.5 in. which narrowed to a diameter of 1 in. (2.54 cm).

The beds were filled with Takeda 3A carbon molecular sieve (mesh size 16-40). Six valves (Whitey SS-92M4-C) were used in conjunction

with solenoid actuators (Numatics 11SAD4410) which were mounted above the beds on a metal plate. These actuators were activated by a valve controller (Solenoid Timer USAF/SAM File No. 82-42).

A gas regulator (Norgren R12-400-RGLA) was used to adjust the inlet air pressure. The inlet air pressure was measured by a pressure gauge (Wallace and Tiernan 61A-1A-0150). The inlet air passed through a mass flowmeter (Technology, Inc. Model LFC-6) and an inlet plenum (500 cubic in./8193.53 cm^3). The inlet plenum stabilized the inlet pressure to the adsorbent beds. Next, the air passed through the adsorbent bed where the oxygen portion was preferentially adsorbed. A portion of the product flow passed through the purge orifice (microbore tubing with 0.028 in. ID) to help desorb the oxygen from the other depressurized bed. Because PSA is a cyclic process the two beds alternately cycle through steps of pressurization and depressurization. The product gas passed through the product flow valve (Whitey SS-21RS4) and a rotameter (Fischer 0-1200 ACCM). A medical gas analyzer (Perkin-Elmer MGA 1100) was used to measure the concentrations of nitrogen, oxygen, and argon in the product gas. The accuracy of the MGA was $\pm$ 0.1%. The system performance may be modified by changing the inlet pressure, product flow, or cycle time.

IV. RESULTS

The percentage of oxygen in the product gas was greatly reduced when the purge orifice (microbore tubing) was applied to the apparatus. Without the purge, the apparatus began to concentrate oxygen. Overall, with the purge orifice installed the oxygen concentration in the product gas ranged from 17.1 to 11.8%.

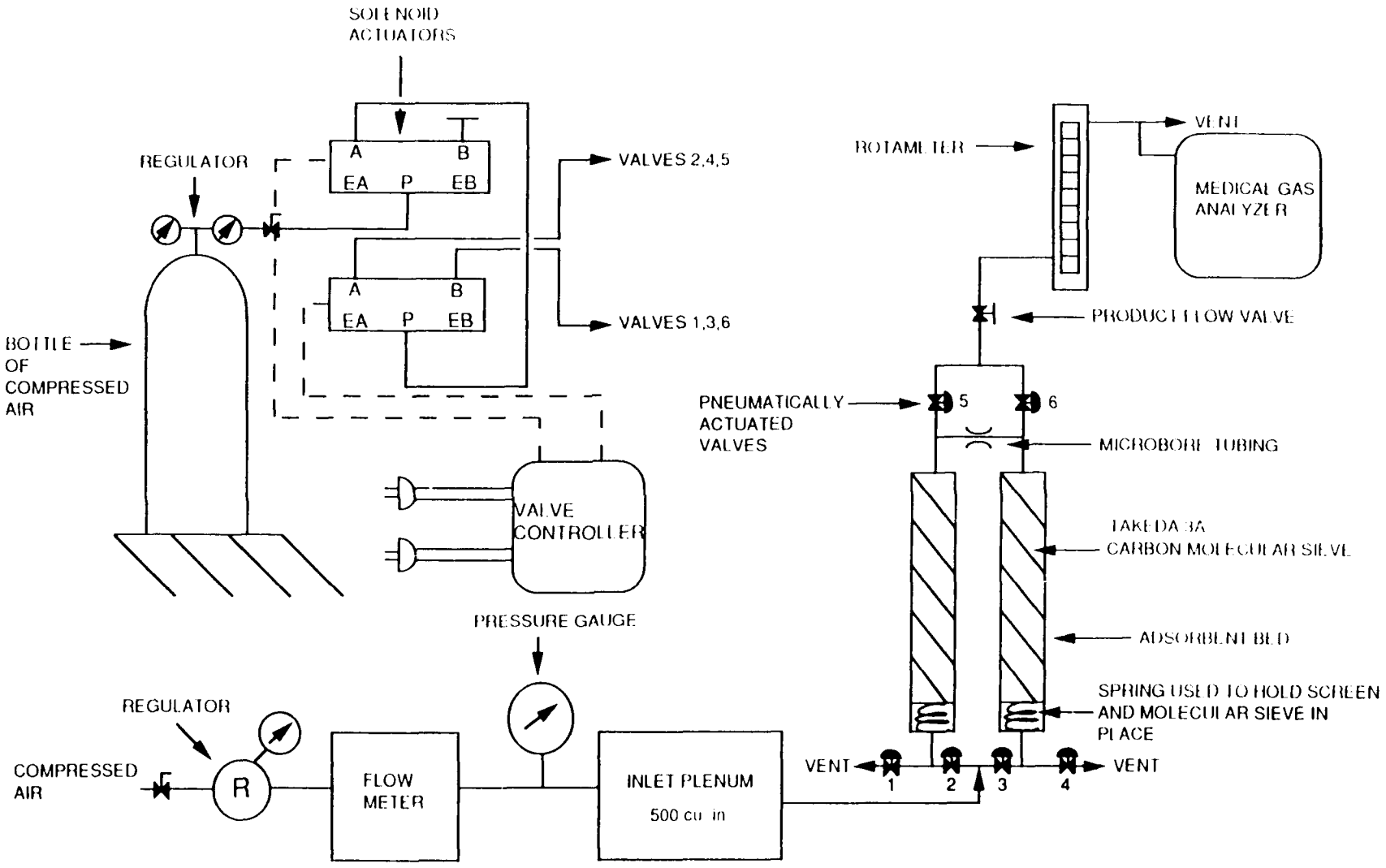
The experimental PSA apparatus performed poorly at cycle times less than 6 seconds. Increased amounts of inert gas were seen at longer cycle times. The system performed better at higher inlet pressures. The oxygen concentration of the product gas appeared relatively insensitive to variations in the mass flow of the product gas. Although the oxygen concentration did decrease gradually as the product flow increased.

Towards the end of the experiment, there were some problems with the rotameter and the inlet air flowmeter. Therefore, some of the reported inlet flows and product flows may be inaccurate.

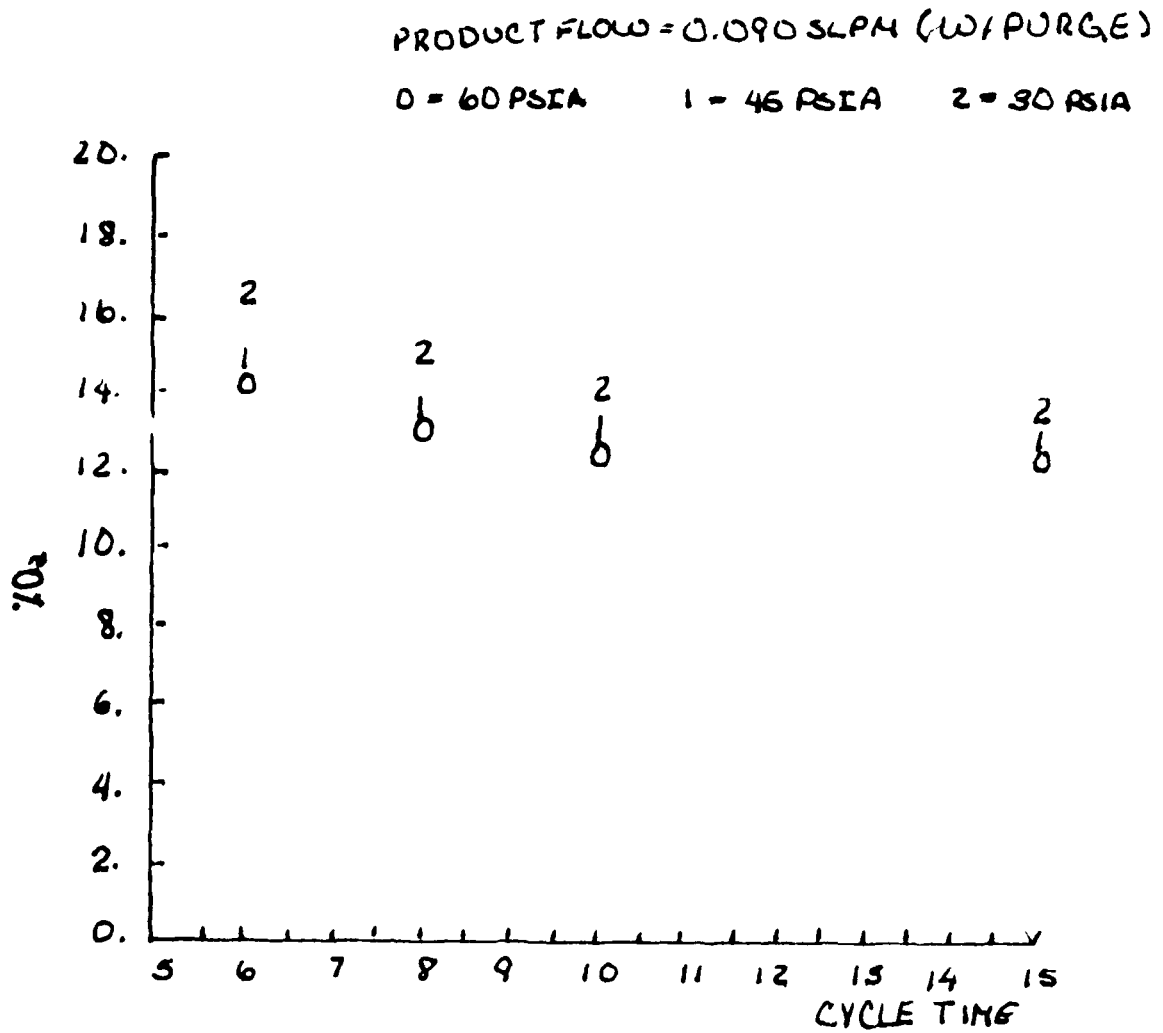
V. CONCLUSIONS

Generally, the experimental PSA apparatus worked better with higher inlet pressures and longer cycle times. The lowest oxygen concentration of, 11.8% occurred with an inlet pressure of 60 psia and cycle time of 15 seconds. Without the purge orifice installed the apparatus began concentrating oxygen.

Although a 9% product oxygen concentration was not observed, a complete analysis of the PSA technique using CMS could not be accomplisned due to the limited time of the program.

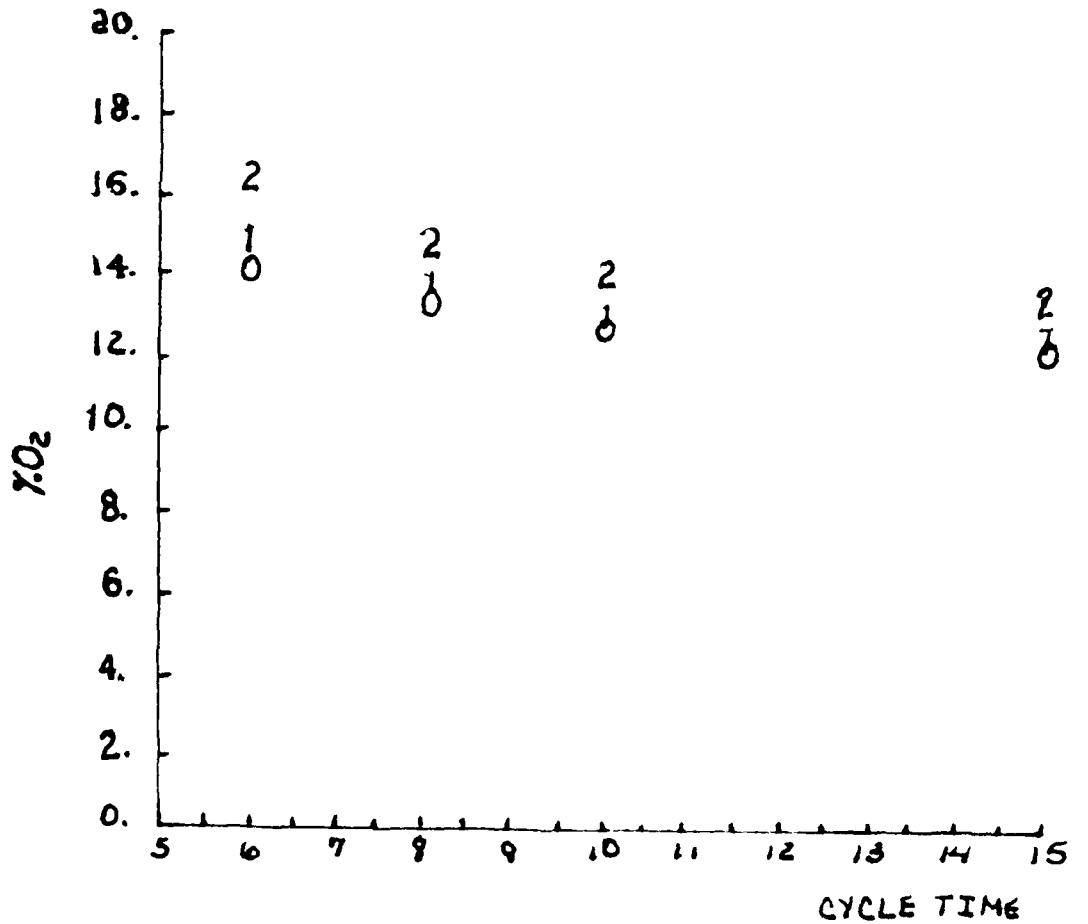


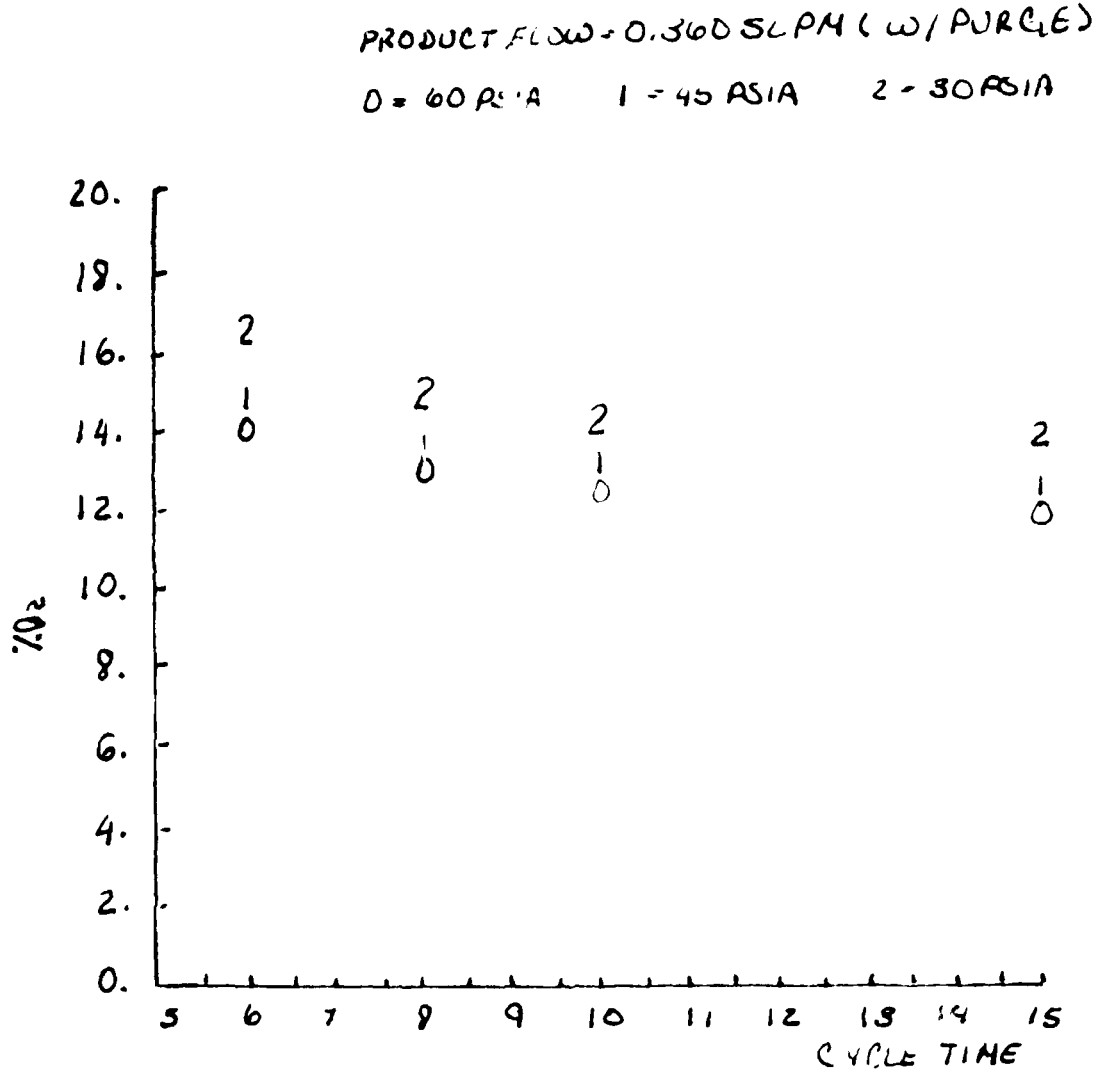
EXPERIMENTAL OBIGGS APPARATUS


PRODUCT FLOW = 0.090 SLPM (W/ PURGE)
0 = 60 PSIA
1 = 46 PSIA
2 = 30 PSIA
%O2
20.
18.
16.
14.
12.
10.
8.
6.
4.
2.
0.
5
6
7
8
9
10
11
12
13
14
15
CYCLE TIME

PRODUCT FLOW = 0.180 SLPM (W/ PURGE)

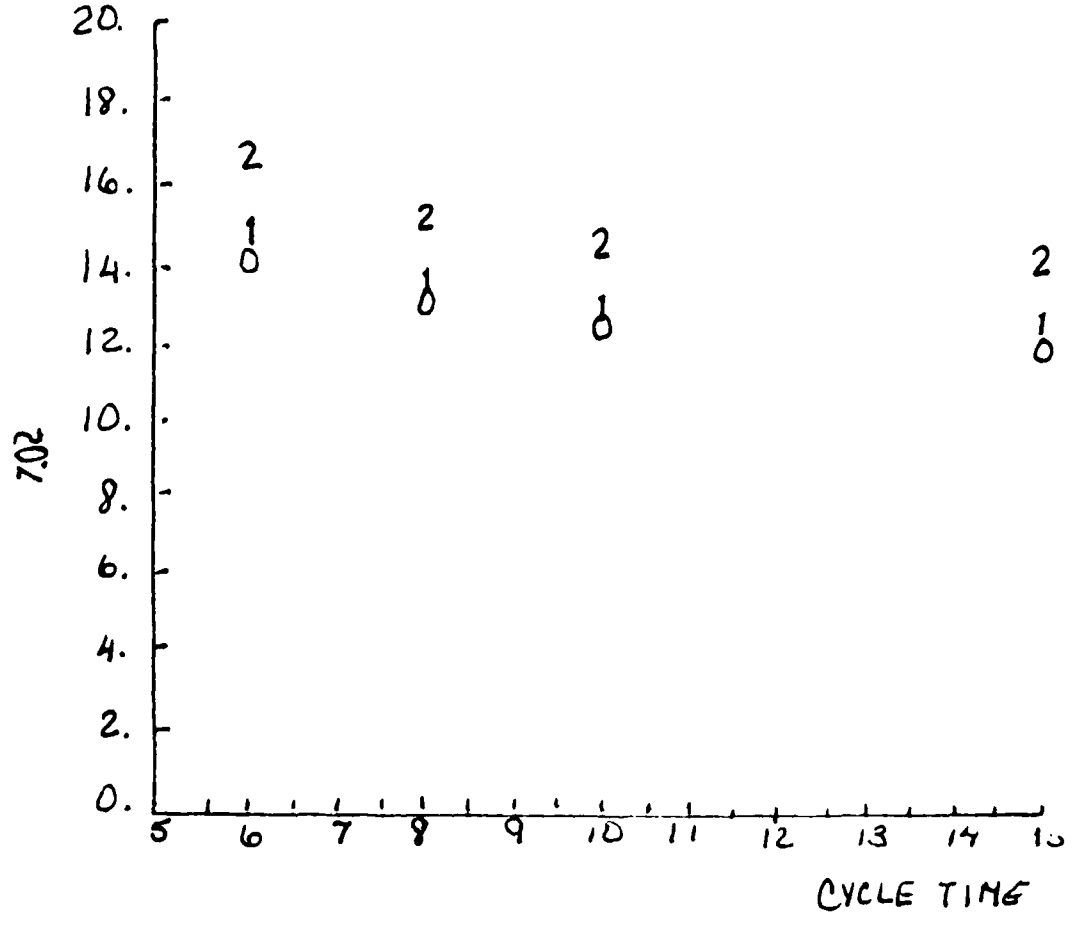
0 = 60 PSIA 1 = 45 PSIA 2 = 30 PSIA

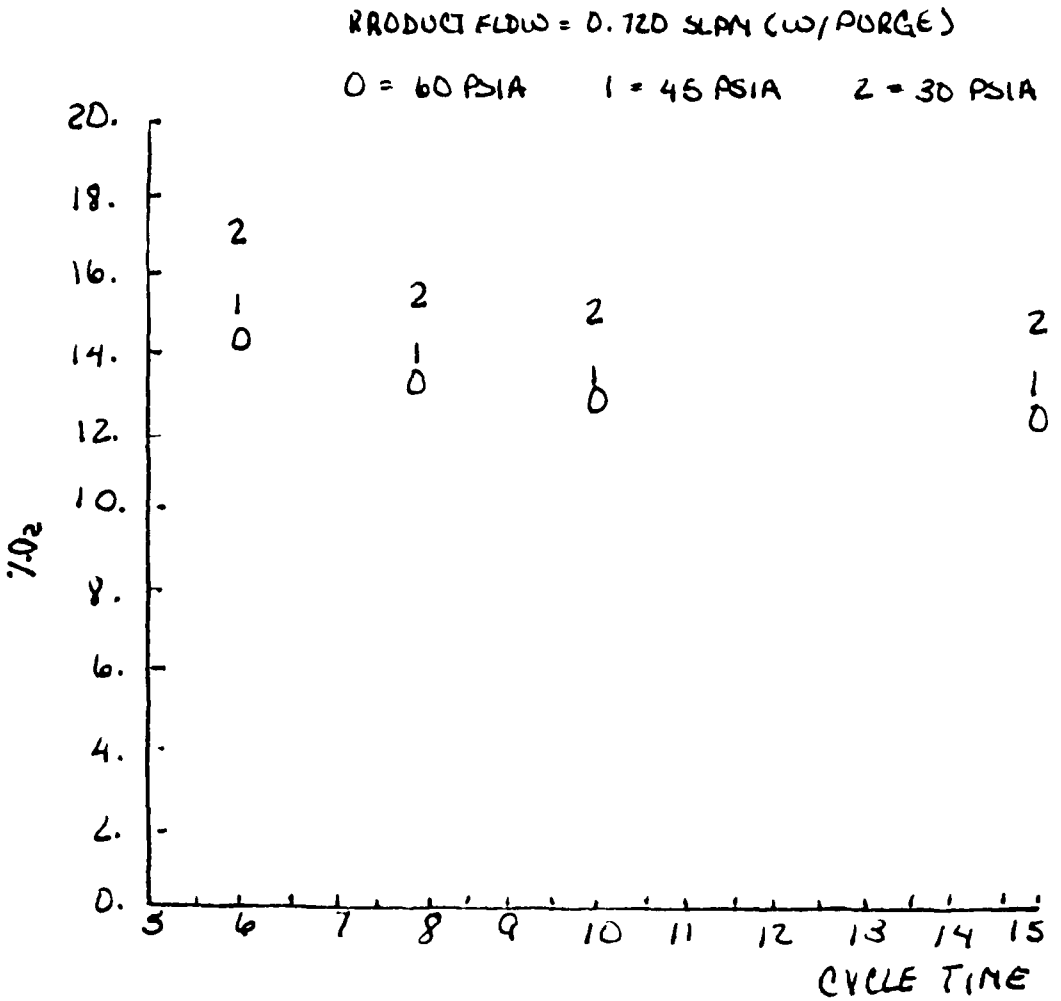



PRODUCT FLOW - 0.360 SLPM (W/ PURGE)
0 = 60 PSIA 1 = 45 PSIA 2 = 30 PSIA
20.
18.
16.
14.
12.
10.
8.
6.
4.
2.
0.
%O2
2
1
0
2
1
0
2
1
0
2
1
0
5 6 7 8 9 10 11 12 13 14 15
CYCLE TIME

PRODUCT FLOW = 0.540 SLPM (W/ PURGE)

0 = 60 PSIA 1 = 46 PSIA 2 = 30 PSIA

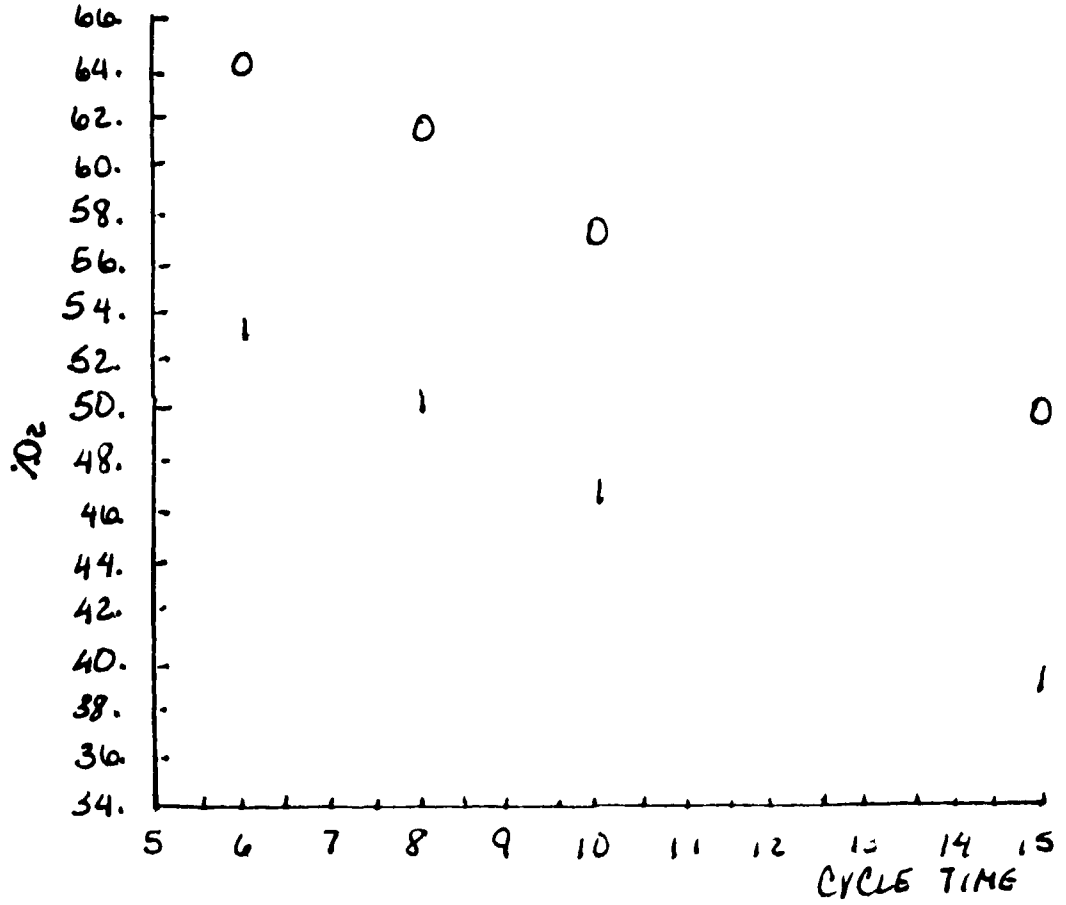



PRODUCT FLOW = 0.720 SLPM (W/ PURGE)
0 = 60 PSIA
1 = 45 PSIA
2 = 30 PSIA
20.
18.
16.
14.
12.
10.
8.
6.
4.
2.
0.
%O2
5
6
7
8
9
10
11
12
13
14
15
CYCLE TIME

PRESSURE = 30 PSIA (NO PURGE)

0 = PRODUCT FLOW OF 0.090 SLPM

1 = PRODUCT FLOW OF 0.180 SLPM



APPENDIX A

ACTUAL DATA

INLET PRESSURE (PSIA)	CYCLE TIME (SEC)	INLET FLOW (SLPM)	PRODUCT FLOW (SLPM)	%N2	%O2	%AR	TOT
WITH PURGE							
30	6	4.46	0.090	82.3	16.6	0.99	99.9
30	8	3.94	0.090	84.0	15.0	1.00	100.0
30	10	3.50	0.090	84.8	14.1	1.01	99.9
30	15	2.85	0.090	85.4	13.5	1.01	99.9
30	6	4.51	0.180	82.5	16.4	0.98	99.9
30	8	3.90	0.180	84.2	14.8	1.00	100.0
30	10	3.46	0.180	84.9	14.0	1.01	99.9
30	15	3.11	0.180	85.5	13.4	1.01	99.9
30	6	4.47	0.360	82.2	16.7	0.98	99.9
30	8	3.85	0.360	83.8	15.1	1.00	99.9
30	10	3.67	0.360	84.6	14.3	1.01	99.9
30	15	3.15	0.360	85.1	13.9	1.01	100.0
30	6	4.99	0.540	82.2	16.9	0.97	100.1
30	8	4.20	0.540	83.7	15.3	0.99	100.0
30	10	3.77	0.540	84.3	14.7	1.00	100.0
30	15	3.37	0.540	84.6	14.3	1.01	99.9
30	6	5.30	0.720	81.9	17.1	0.97	100.0
30	8	4.64	0.720	83.3	15.5	0.98	99.8
30	10	4.20	0.720	83.9	15.0	0.99	99.9
30	15	3.64	0.720	84.3	14.7	1.00	100.0
45	6	9.77	0.090	84.1	14.9	0.99	100.0
45	8	8.50	0.090	85.3	13.6	1.01	99.9
45	10	7.36	0.090	85.9	13.1	1.02	100.0
45	15	6.75	0.090	86.3	12.7	1.02	100.0
45	6	10.03	0.180	84.2	14.8	0.99	100.0
45	8	8.94	0.180	85.4	13.6	1.02	100.0
45	10	7.88	0.180	86.0	12.9	1.02	99.9
45	15	6.92	0.180	86.5	12.4	1.02	99.9
45	6	10.29	0.360	84.1	14.9	1.00	100.0
45	8	8.72	0.360	85.3	13.6	1.02	99.9
45	10	7.93	0.360	86.0	13.1	1.02	100.1
45	15	7.01	0.360	86.5	12.5	1.03	100.0
45	6	10.51	0.540	83.9	15.0	0.99	99.9
45	8	8.94	0.540	85.2	13.7	1.01	99.9
45	10	7.88	0.540	85.6	13.1	1.02	99.7
45	15	7.10	0.540	86.1	12.7	1.02	98.8
45	6	10.51	0.720	83.6	15.2	0.99	99.8
45	8	9.37	0.720	85.0	14.0	1.00	100.0
45	10	8.32	0.720	85.5	13.4	1.01	99.9
45	15	5.96	0.720	86.0	13.1	1.01	100.1
60	6	15.68	0.090	84.9	14.1	1.01	100.0
60	8	13.58	0.090	86.1	12.9	1.02	100.1
60	10	12.00	0.090	86.5	12.4	1.03	99.9
60	15	10.77	0.090	86.7	12.2	1.03	99.9
60	6	16.12	0.180	84.9	14.0	1.01	99.9

INLET PRESSURE (PSIA)	CYCLE TIME (SEC)	INLET FLOW (SLPM)	PRODUCT FLOW (SLPM)	%N2	%O2	%AR	SUM
			WITH PURGE				
60	6	13.45	0.180	85.9	13.1	1.01	100.0
60	10	12.09	0.180	86.5	12.5	1.03	100.0
60	15	10.60	0.180	86.9	12.1	1.03	100.0
60	6	18.48	0.360	84.9	14.1	1.01	100.0
60	8	13.84	0.360	86.1	12.9	1.02	100.0
60	10	12.35	0.360	86.6	12.4	1.03	100.0
60	15	10.60	0.360	87.2	11.8	1.03	100.0
60	6	18.66	0.540	84.8	14.2	1.00	100.0
60	8	15.20	0.540	86.0	13.1	1.02	100.1
60	10	12.57	0.540	86.5	12.5	1.03	100.0
60	15	11.08	0.540	87.0	12.0	1.03	100.0
60	6	16.25	0.720	84.7	14.3	1.00	100.0
60	8	16.56	0.720	85.6	13.2	1.01	99.8
60	10	12.70	0.720	86.3	12.7	1.03	100.0
60	15	11.21	0.720	86.8	12.3	1.03	100.1
			NO PURGE				
30	6	2.63	0.090	35.5	64.2	0.35	100.1
30	8	1.84	0.090	37.8	61.8	0.37	100.0
30	10	1.66	0.090	42.1	57.4	0.41	99.9
30	15	1.37	0.090	49.4	50.0	0.48	99.9
30	6	2.93	0.160	45.8	53.4	0.46	99.7
30	8	1.93	0.180	48.9	50.6	0.49	100.0
30	10	1.75	0.180	52.5	46.9	0.53	99.9
30	15	1.84	0.180	59.3	39.4	0.62	99.3

APPENDIX B

PRELIMINARY DATA

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100 ml - 62.5 g, 62.4 g
0.625 g/ml, 0.624 g/ml

75 ml - 46.7 g, 47.9 g
0.623 g/ml, 0.639 g/ml

50 ml - 31.4 g, 32.0 g
0.628 g/ml, 0.640 g/ml

B U L K D E N S I T Y = 0 . 6 3 0 g / m l

MASS OF CARBON MOLECULAR SIEVE BEDS

1ST BED W/SIEVE - 1129.6 g SIEVE (3A CMS) - 153.6 g

2ND BED W/SIEVE - 1130.3 SIEVE (3A CMS) - 154.3 g

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SUMMER HIGH SCHOOL APPRENTICESHIP PROGRAM

FINAL REPORT

Affects of Anti-G Straining Maneuvers on Blood Pressures in Man; Affects of +Gz on the Cardiovascular System of Baboons

Apprentice: Matt Felder

Mentor(s): Dr. Ricky Latham &

Dr. Bernard Rubal

Date: June 18 - Aug 10

Acknowledgements

I would like to thank Dr. Latham, Dr. Rubal, Sgt. Goff, Sgt. Owens, Capt. Barber, J. McGlothan, C. White, A. Pennington and the rest of the LACR staff that I have worked with these eight weeks for making it easy for me to fit in and help out, as well as for teaching me so much about science and research. I would also like to thank the High School Apprenticeship Program for providing me with such an excellent opportunity. I will never loose what I have learned this summer and will undoubtedly continue to benefit from it.

Introduction

During the eight weeks in which I have been working with Dr. Latham and Dr. Rabal, I have collaborated on two main projects. The first of these was a more long term project, "The Affect of +Gz on the Cardiovascular System in Baboons," which this division is working on now.

The second effort was a smaller project which Dr. Latham and I began. This focused on data collected at Brooke Army Medical Center from Army pilots during elective heart catheterization. The data was used to determine the effects of routine anti-G straining maneuvers on blood pressures. The timeline on the following page outlines the major events during the course of my stay here.

When I arrived at Brooks Air Force Base, I was introduced to much of the equipment which is used for research. I was able to see the centrifuge and watch a video tape of a centrifuge run up to nine Gz, with a resulting blackout. The centrifuge is able to achieve the same level of +Gz as a high performance aircraft, because of the minimal distance of the radial arm. The formula for $\text{radial acceleration} = v^2/r$ centrifugal force at the right shows that decreasing the radius of the turn causes an increase in the force (1).

A black out under G force stress is caused by the body's inability to continue to supply blood to the brain. The G forces overcome the blood pressure inside the vessels supplying blood to the brain at approximately five Gz or

below. If a G suit is worn, this threshold is raised approximately one G.

A G suit is a tight fabric garment covering the abdomen and legs. The suit has a series of bladders which fill with air as G forces are increased. These bladders help to keep the blood from pooling in the lower extremities. The only other blackout protection is straining maneuver training such as for the valsalva maneuver.

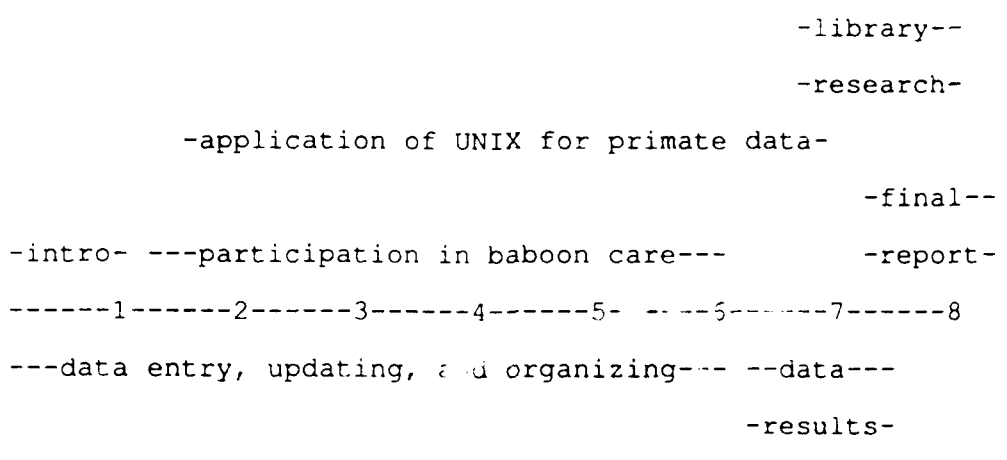
The valsalva maneuver is defined as a maximally forceful exhalation against the completely closed glottis, accompanied by tensing of the lower extremity and abdominal musculature. Other maneuvers have been tested to aid in the prevention of a +Gz induced blackout such as the M-1 and now the L-1 (2). No supported final conclusions have yet been made on what straining maneuver works best for the common pilot.

Researchers are currently developing and testing new ideas for the prevention of GLOC (G induced loss of consciousness). One of these ideas involves the immersion of the pilot in water up to heart level. This is one of the most effective, yet most unlikely method of G-protection. Unfortunately, the weight of the water would be incompatible for use in flight (3).

Another idea for G-protection is the supine or prone position. Seating the pilot in one of these positions allows a G-tolerance of near 15G. This higher G-tolerance is caused by the force being changed from positive Gz to

transverse Gz, which the body is much more capable of withstanding. The downside is that both prone and supine seating greatly or completely restrict the pilot's view and actions (1,4).

Timeline (weeks)



1. Baboon Studies

The long term project "Affects of +Gz on the Cardiovascular System" uses baboons for studying cardiovascular hemodynamics during tilt studies (upright, supine, and headdown), centrifuge runs (+Gz), and KC-135 parabolic flights (0G). The project was begun in March of 1990 and is not scheduled to be completed until the second quarter of fiscal year 1992.

The protocol called for five baboons instrumented with electromagnetic flow probes, crystals, fluid catheters, and hi-fidelity pressure transducers. The crystals served to determine a fairly accurate estimate of cardiac dimensions and thereby ventricular volume. Hi-fidelity pressure transducers were placed into the left ventricle and aorta to provide the blood pressures in those respected areas. Fluid catheters were placed into the right and left atria to record filling pressures and have easy access to blood samples. An electromagnetic flow probe was placed onto the ascending aorta to determine blood flow velocity and cardiac output.

Because of the longevity of this project, I had little opportunity to witness results, but I was able help with the care of the baboons as well as the collection of some tilt study data. Each of these is included in the report.

I was also able to see some computer applications and programming with Dr. Rubal. He developed a series of short

programs which can take digital data from the baboon studies to apply complex and accurate mathematical equations to find such things as tao (time constant of pressure relaxation), peak positive dp/dt and compliance. I also was able to witness the actual implantation of the catheters from the observation galley above the primate operating room. I observed the entire process from setup, sterile draping, and first incision to final suturing. This taught me quite a bit about the technical complexity of the project and how important the sterile need is to prevent infection as well as common surgery procedures.

2. Baboon Care

Each baboon was instrumented with two fluid catheters, into the right atrium and left atrium. These catheters needed to be cleansed twice a week to prevent and or remove blood clots. At the same time, the animal was checked for infection, weighed, measured, and grooled (force fed) as needed. The procedure for the baboon care was as follows:

1. lab preparation
    A. all equipment prepared
        1. equipment unpackaged
            a. 3- 3cc syringes
            b. 3- 10cc syringes
            c. 3- 23 gauge needles
            d. 3- 18 gauge needles
            e. packing cloths (sterile towels)
            f. sutures
        2. other equipment arranged
            a. needle holders
            b. hydrogen peroxide
            c. povidone solution
            d. povidone ointment
            e. clamps
        3. needles attached to syringes

4. syringes drawn up

a. 1- 2cc ketamine

b. 2- 2cc heparin

c. 1- 3cc heparinized saline

d. 2- 10cc heparinized saline

2. animal sedated

A. animal held immobile

B. 2cc of ketamine administered (intramuscular)

C. wait until no stimulus response

D. remove from cage

3. animal brought into lab room and placed onto table

4. sutures cut, jacket opened and unpacked

5. fluid caths unwrapped

6. remove PRN

7. attach syringe with 3cc heparinized saline

8. draw back to remove clots

9. administer 10cc heparinized saline through catheter

10. attach new PRN

11. administer 2cc heparin through catheter

12. rewrap catheter

13. repeat steps 6-12 for other catheter

14. check for infection

15. shave skin around catheter entrances if needed

16. apply povidone ointment to entrances

17. spray area with povidone solution

18. weigh and measure if needed

19. repack catheters into vest

20. close vest and suture

21. return animal to cage

22. clean up

3. Baboon Tilt Study Data Collection

Each Baboon was tilted on scheduled dates. Some of these tilts were only for training, with no data collection or instrumentation, but others required full attachment and calibration of catheter probes. I actively participated in the preparation of the studies, but the instrumentation was performed only by the engineers and catheter technicians. The following is the procedure for the tilt studies:

1. tilt chair prepared (attached to tilt table)
2. allow for electrical equipment preparation
3. sedate animal (2cc ketamine, intramuscular)
4. animal brought in and backpack opened
5. catheters unpacked and unwrapped
6. animal placed into chair
7. instruments hooked up and calibrated
8. as animal comes around, food is given as wanted
9. data collected
10. animal sedated after studies completed
11. removed from chair and returned to cage
12. clean up

4. Human Studies

Affects of Anti-G Straining Maneuvers on Blood Pressures

All data used in this experiment was collected by Dr. Latham at Brooke Army Medical Center Cardiac Catheterization Laboratory at Fort Sam Houston. All patients were male Army pilots undergoing an aeromedical heart catheterization. Subjects were asked to perform a set of straining maneuvers which consisted of a valsalva only held, an L-1 held, a valsalva with three second breathing intervals, and an L-1 with three second breathing intervals. Blood pressures were recorded as a function of time using a Honeywell fiberoptic UV recorder onto light sensitive paper (Example of tracing for valsalva with breathing and L-1 with breathing attached to report). The systolic and diastolic blood pressures were measured from the graphs by hand and recorded onto paper. This data was then entered into Lotus 1,2,3. Average blood pressures were determined for intervals of one second and the standard deviations were calculated. This data was also used with Sigma Plot to obtain a graphical output. A total of twelve graphs of blood pressures were plotted each as a function of time; the list is as follows:

A. _____ Pressures During Valsalva Only Held (no breathing) compared to L-1 Maneuver Held (no breathing) (with standard deviation error bars on time and BP)

1. Systolic Blood
2. Diastolic Blood
3. Pulse

B. _____ Pressures During Valsalva Only with Breathing (with standard deviation error bars on time and BP)

4. Systolic Blood
5. Diastolic Blood
6. Pulse

C. _____ Pressures During L-1 Maneuver with Breathing (with standard deviation error bars on time and BP)

7. Systolic Blood
8. Diastolic Blood
9. Pulse

D. _____ Pressures During Valsalva Only with Breathing compared to L-1 Maneuver with breathing (with no error bars)

10. Systolic Blood
11. Diastolic Blood
12. Pulse

All graphs are attached to report.

5. Results of Human Study

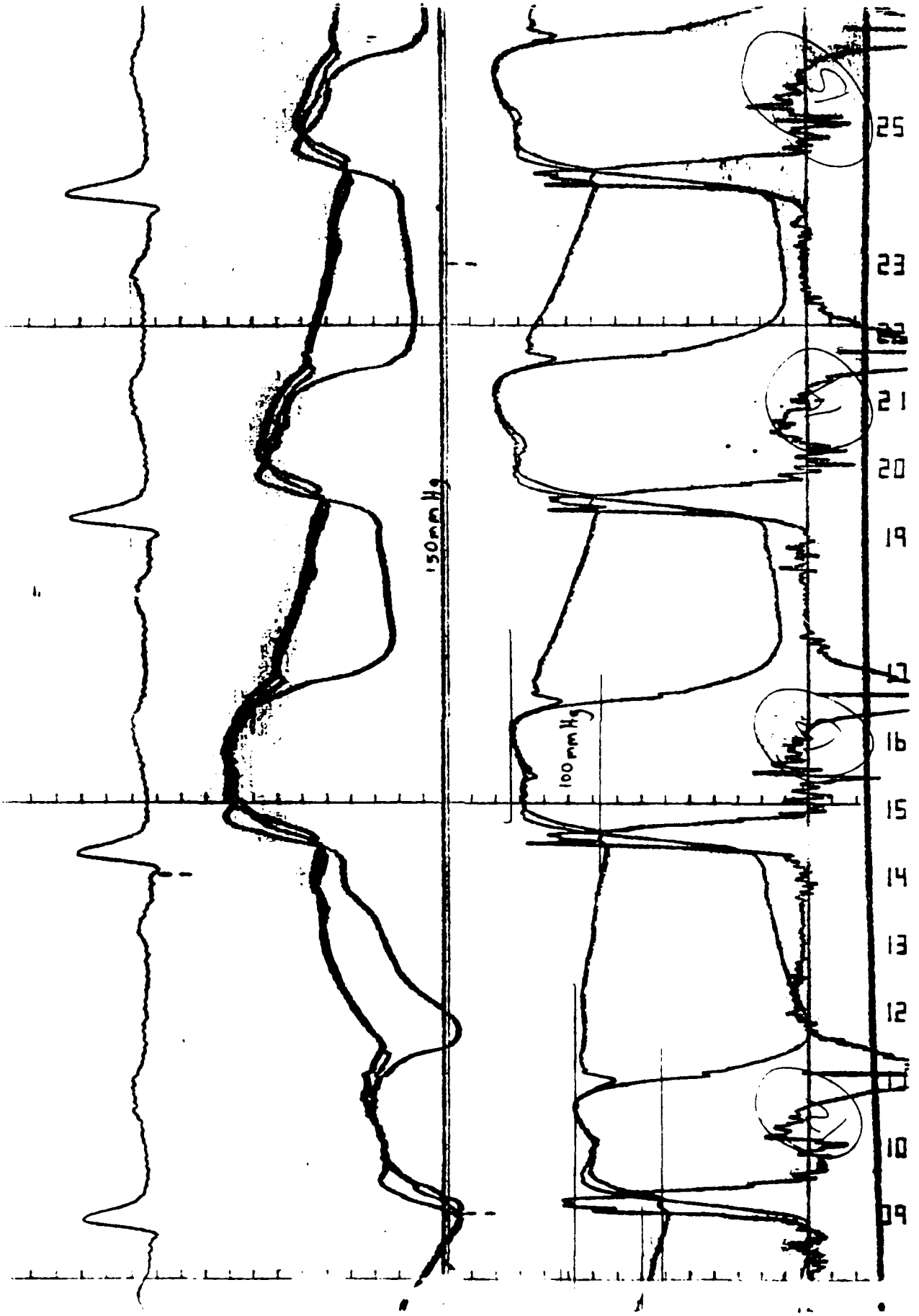
The average baseline systolic blood pressure for the L-1 maneuver with breathing was 144.5 mmHg, while the baseline for the valsalva with breathing was 133.6 mmHg. After straining for one second, both averages rose approximately 25 mmHg. Both average pressures held with a gradual loss until a breath was taken at which time they dropped to their baseline or below. This pattern repeated with a loss of average pressure over time until the strain was completely released at which time the average pressures dropped dramatically. The average diastolic pressures held the same general trend, scaled down.

The pulse pressures held a reverse trend, also scaled down. As the maneuvers were begun, the average pulse pressures dropped approximately 30 mmHg over eleven seconds. This reverse trend was caused by the straining maneuvers decreasing venous return.

After reviewing the collected graphs and tables it seems apparent that any data past six seconds on the "held" graphs is not statistically reliable. This was caused by some of the patients not holding their strain as long as others, causing a sudden drop in blood pressure near the end of the graphs. Until more data can be collected to replace those subjects which released prematurely, only the data up to six seconds on the valsalva maneuver (held) is viable. The L-1 maneuver (held) data also needs more subjects to

produce a more viable graph. The graphs with breathing are usable until fourteen seconds and are then not statically helpful because of a low n.

The rest of the graphs, at this time, show no statistical significance between the valsalva maneuver versus the L-1 maneuver. More data are planned to be collected to reduce the standard deviations and develop more accountable graphs.


150mmHg
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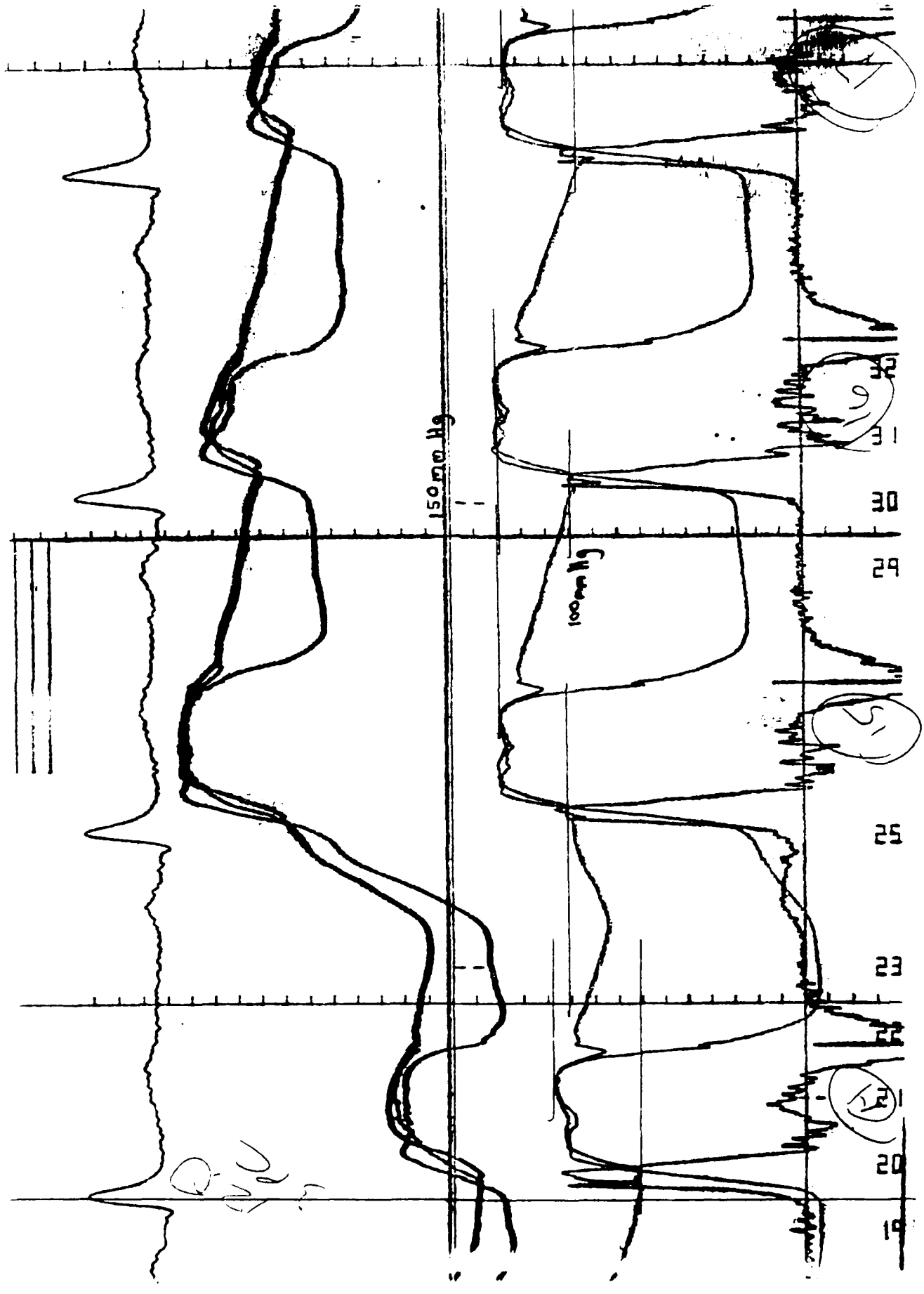
150mm Hg
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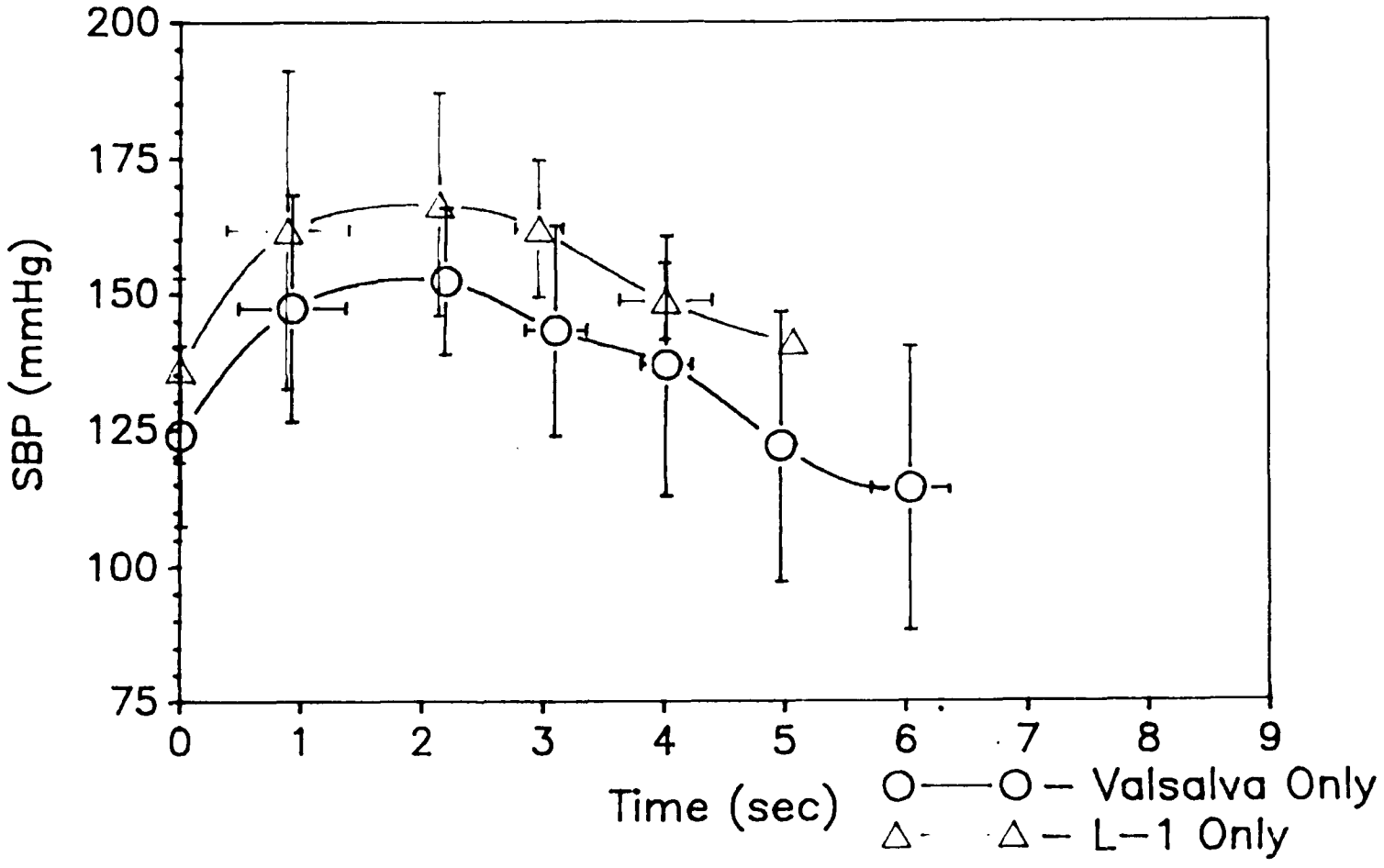
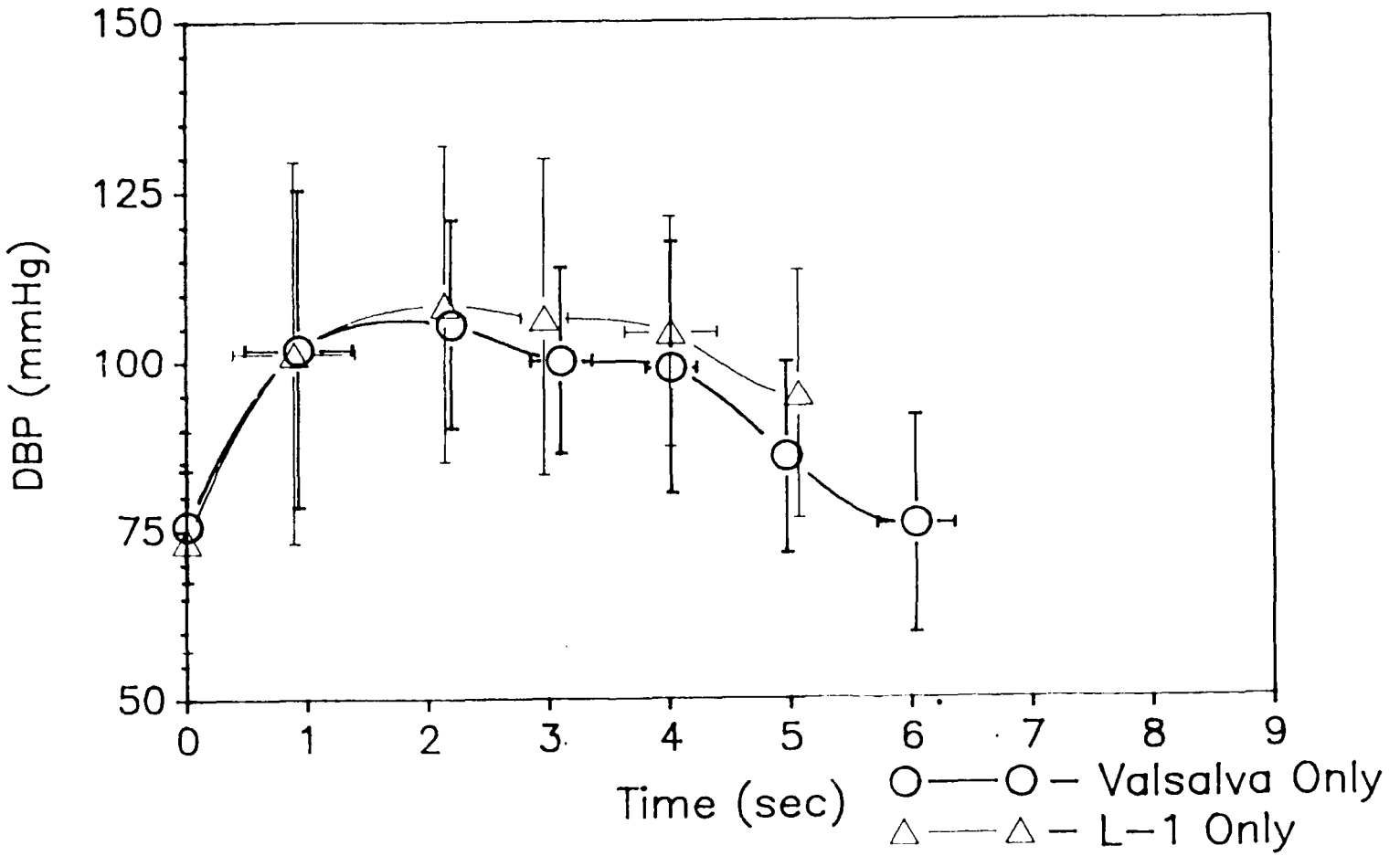
Systolic Blood Pressures
During Straining Manuevers

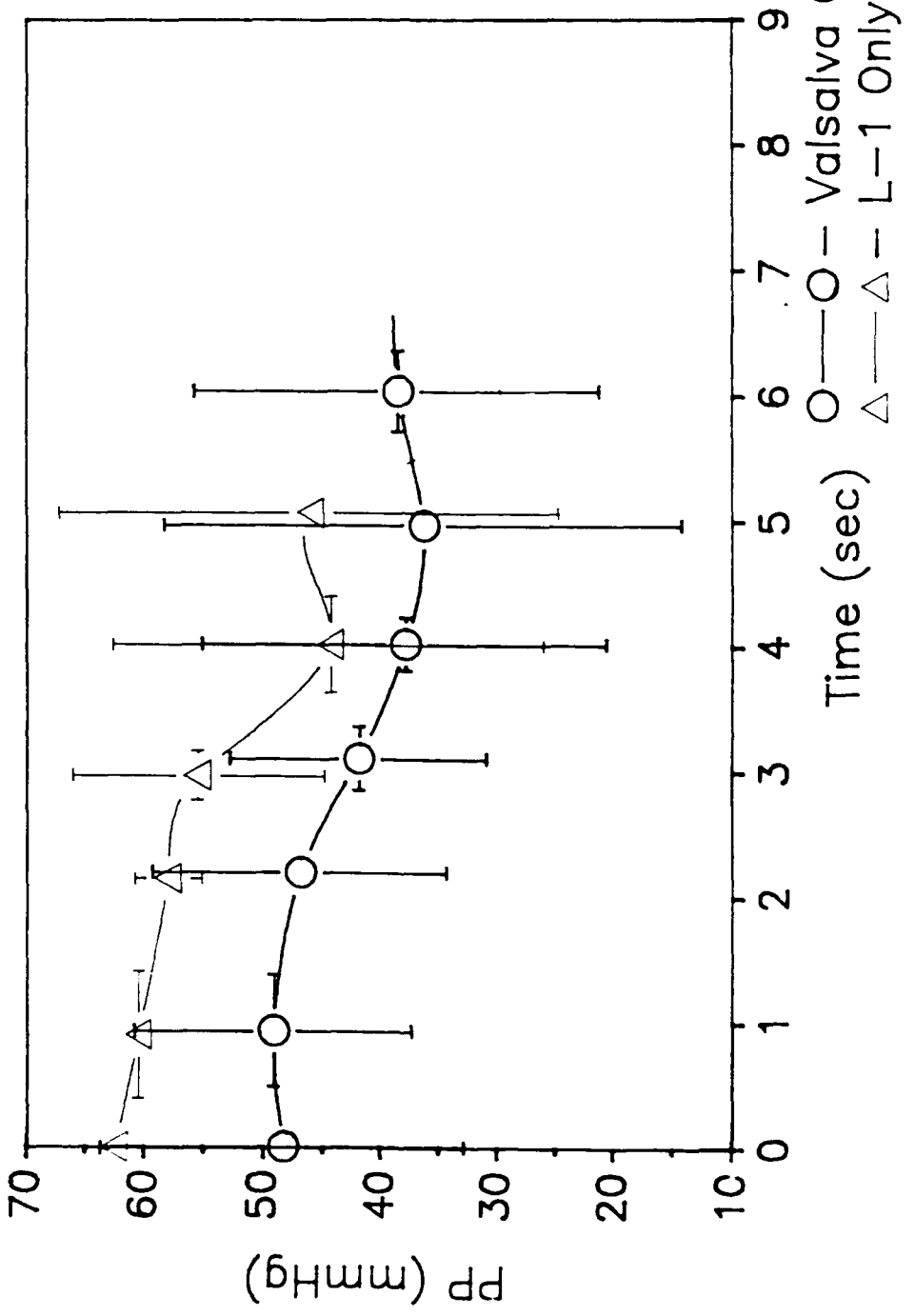


Diastolic Blood Pressures
During Straining Manuevers



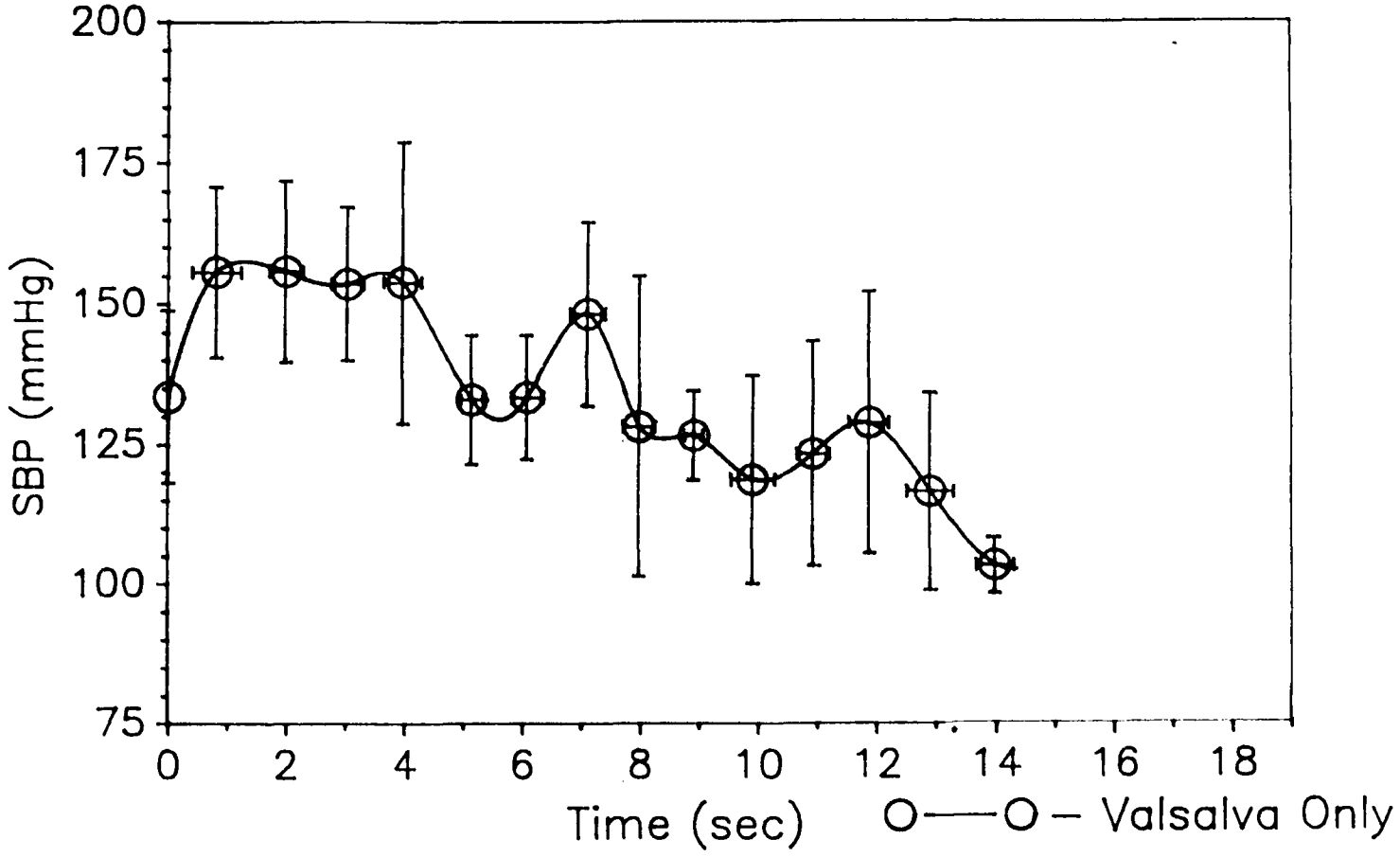
Pulse Pressures

During Straining Manuevers



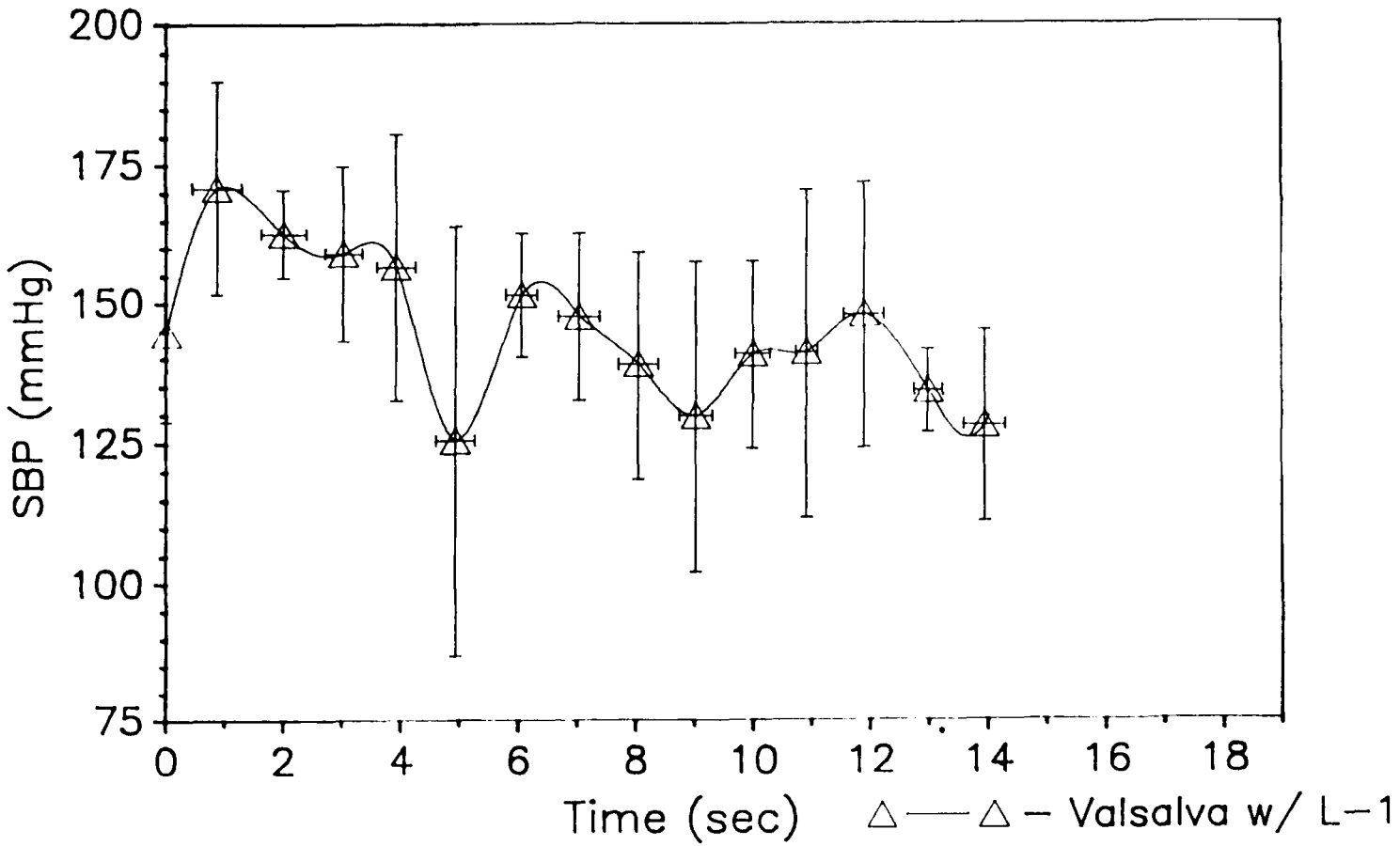
Systolic Blood Pressures

During Straining Manuevers with breathing



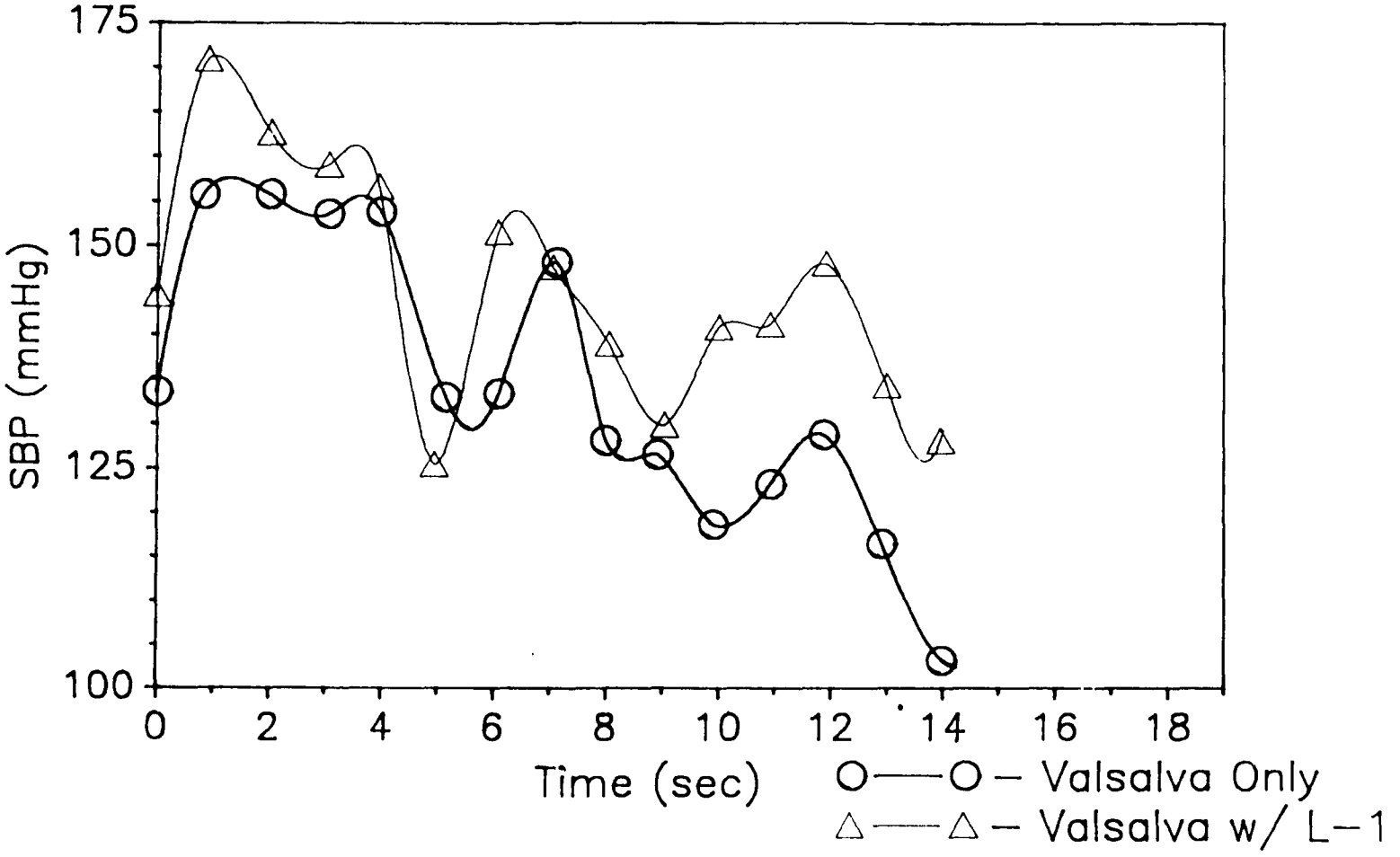
Systolic Blood Pressures

During Straining Manuevers with breathing



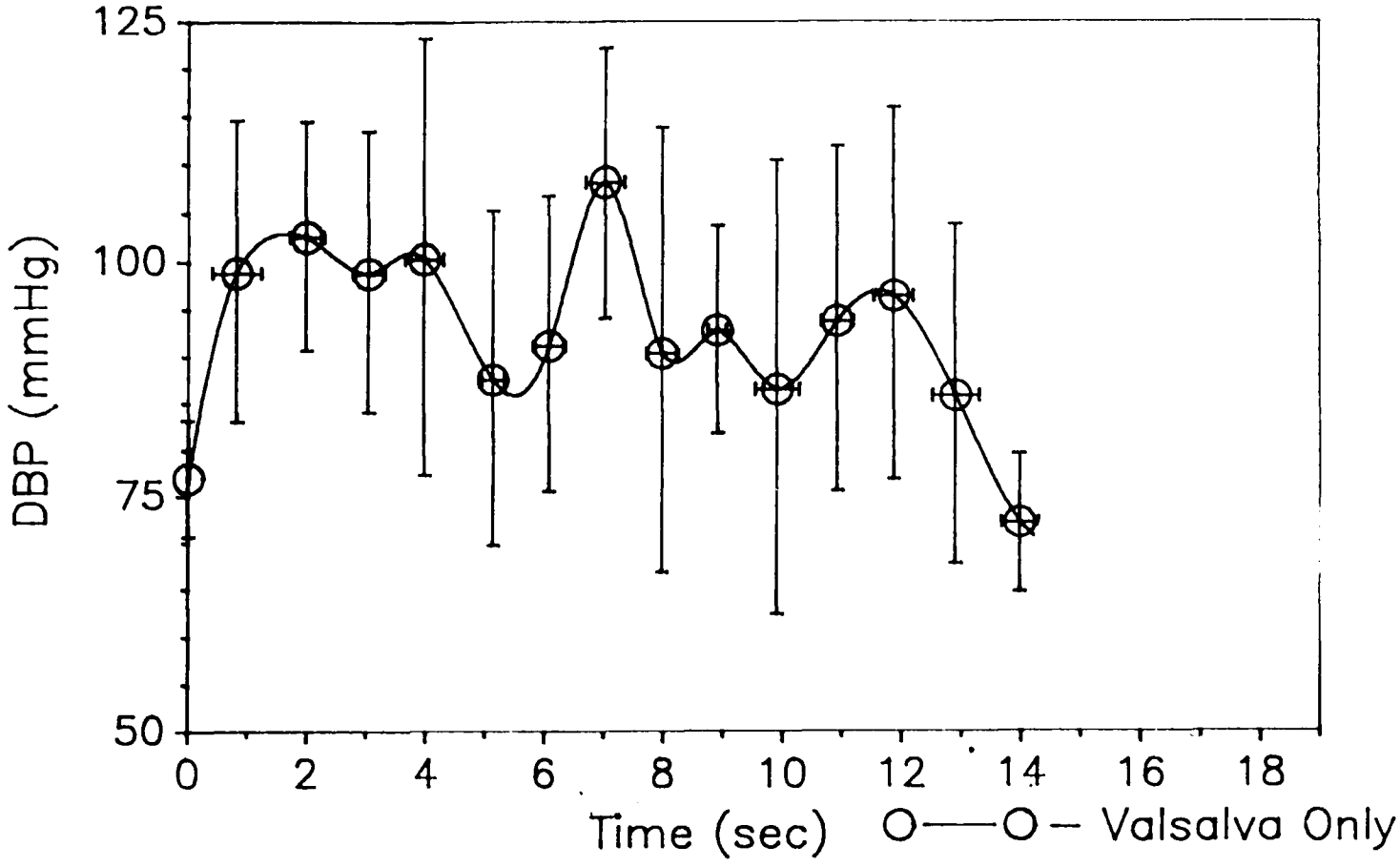
Systolic Blood Pressures

During Straining Manuevers with breathing



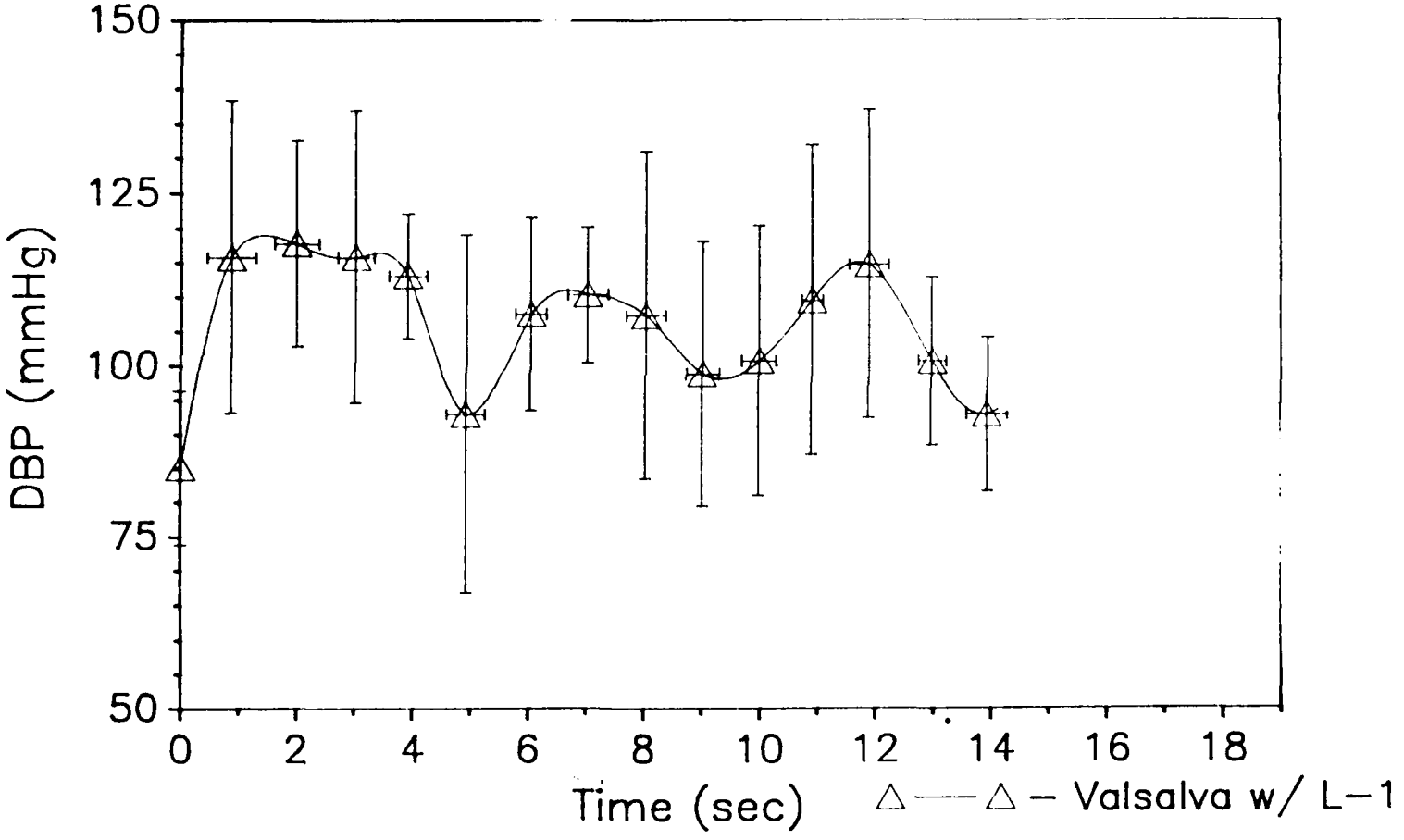
Diastolic Blood Pressures

During Straining Manuevers with breathing



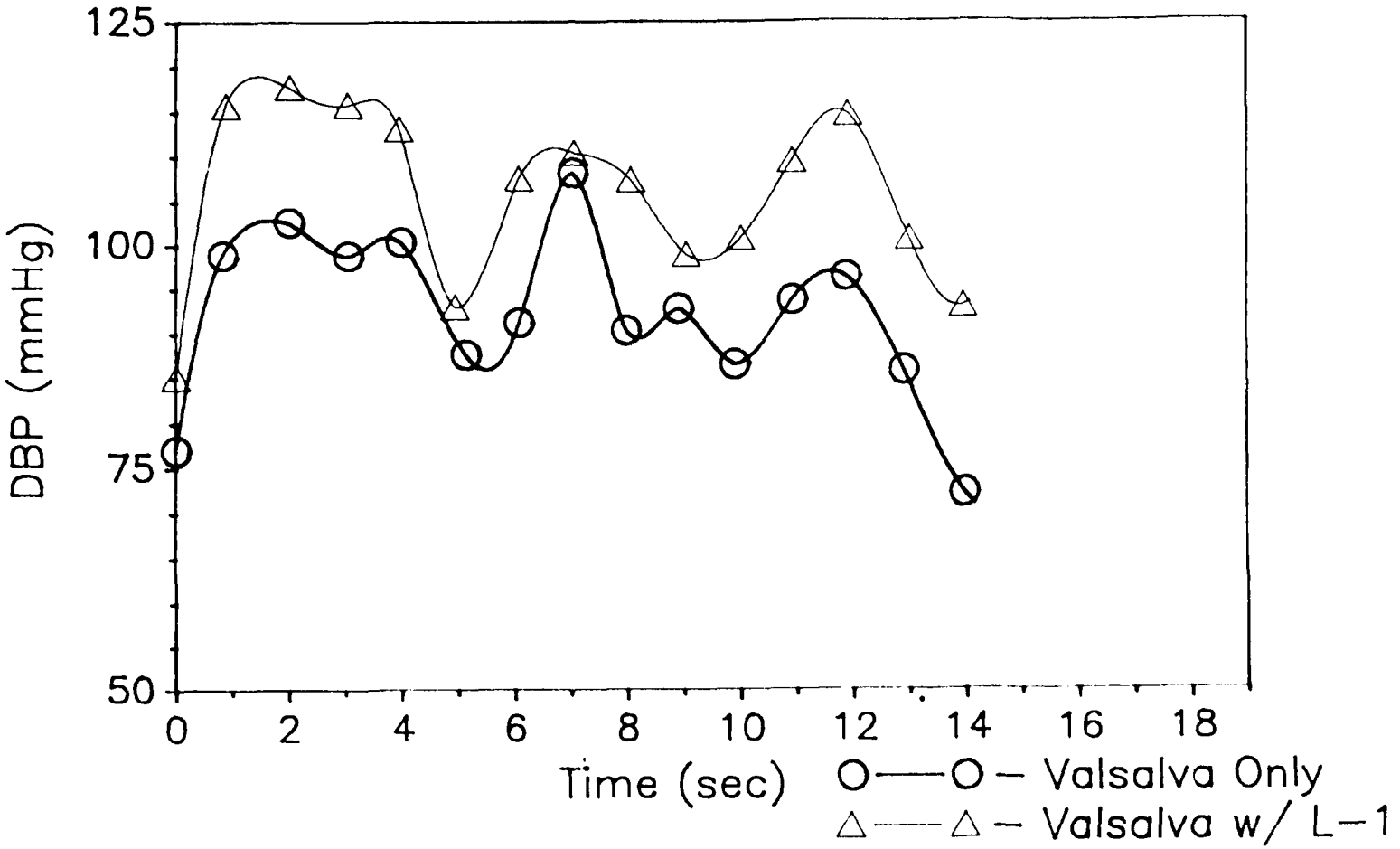
Diastolic Blood Pressures

During Straining Manuevers with breathing



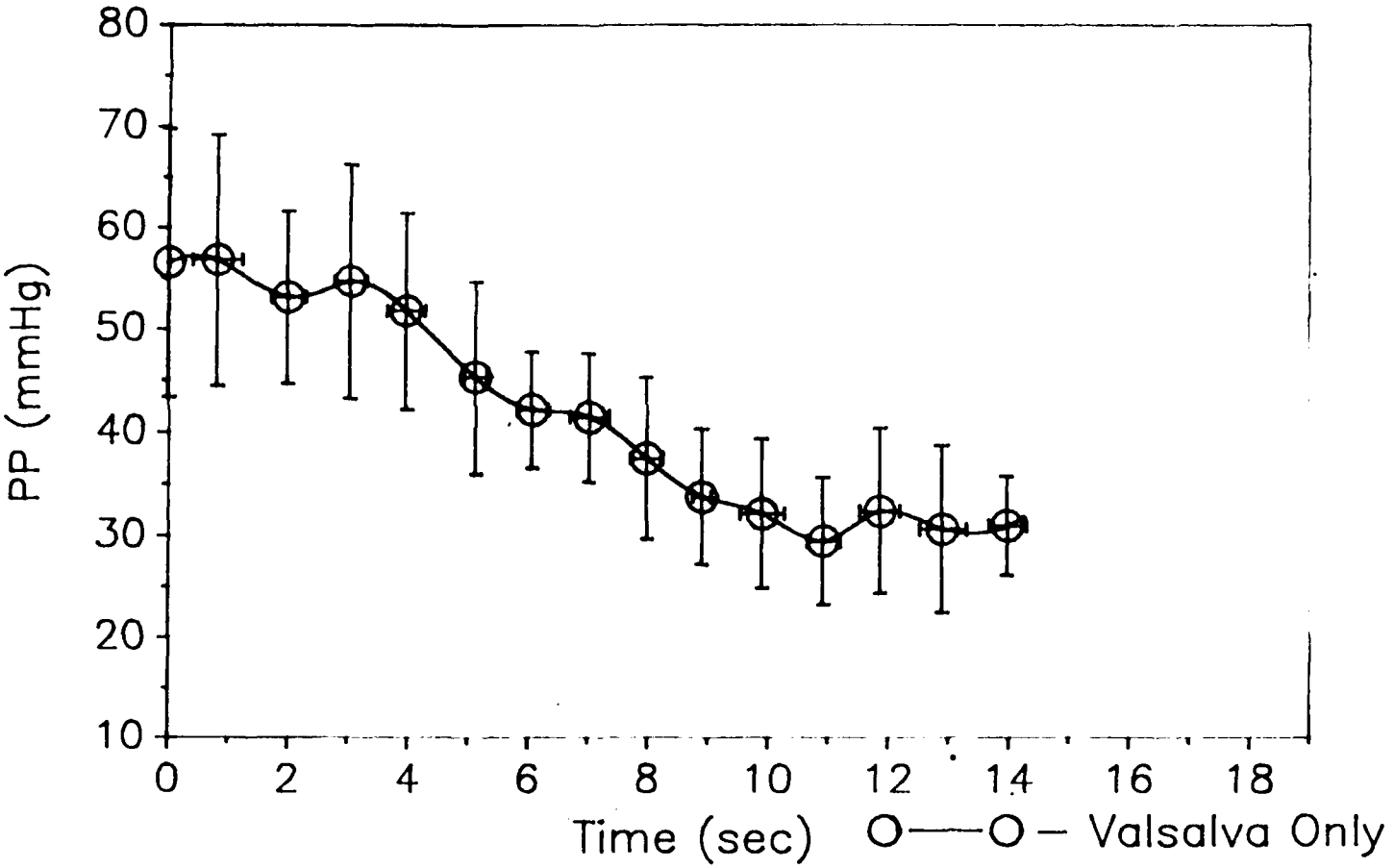
Diastolic Blood Pressures

During Straining Manuevers with breathing



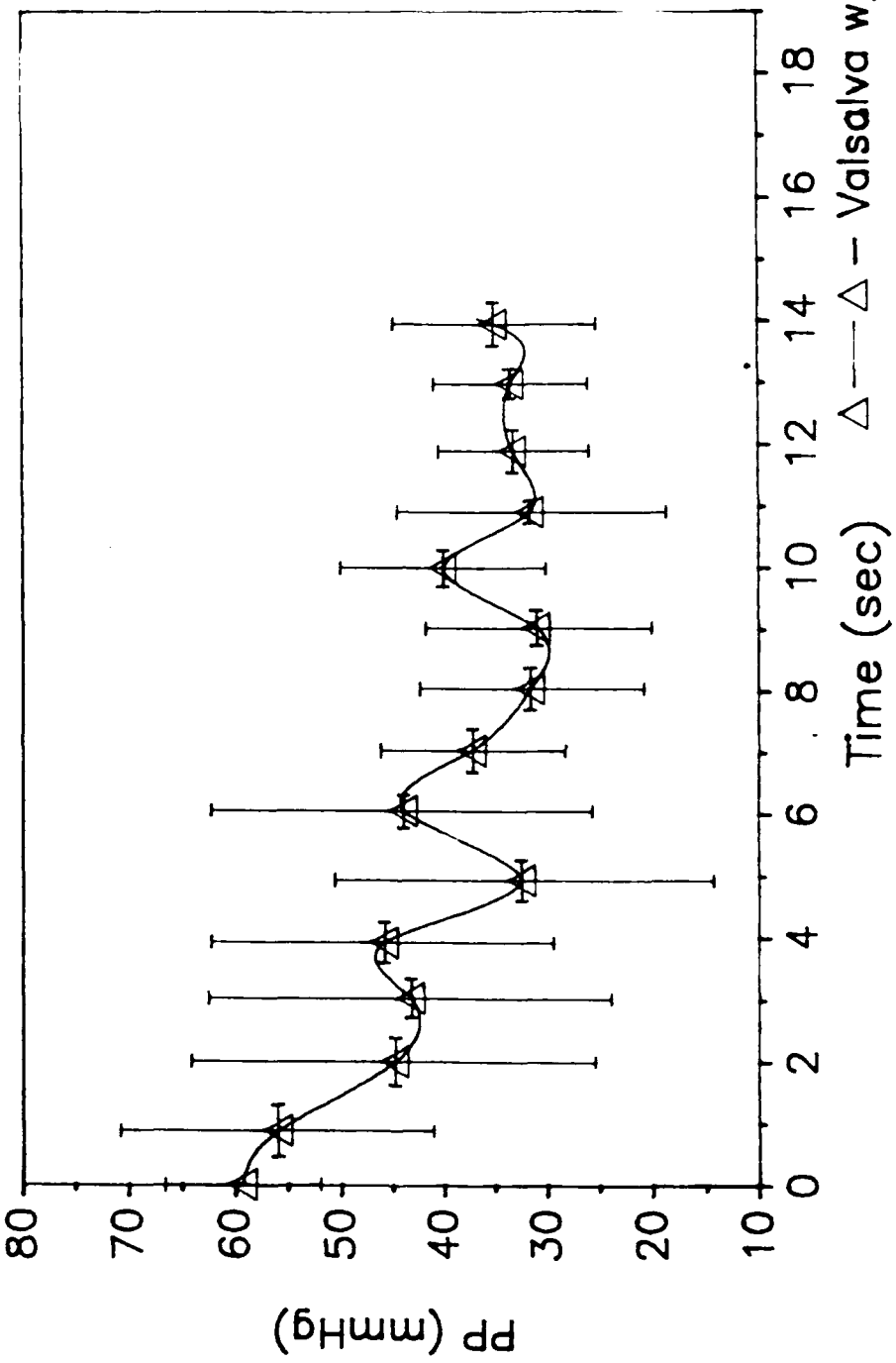
Pulse Pressures

During Straining Manuevers with breathing



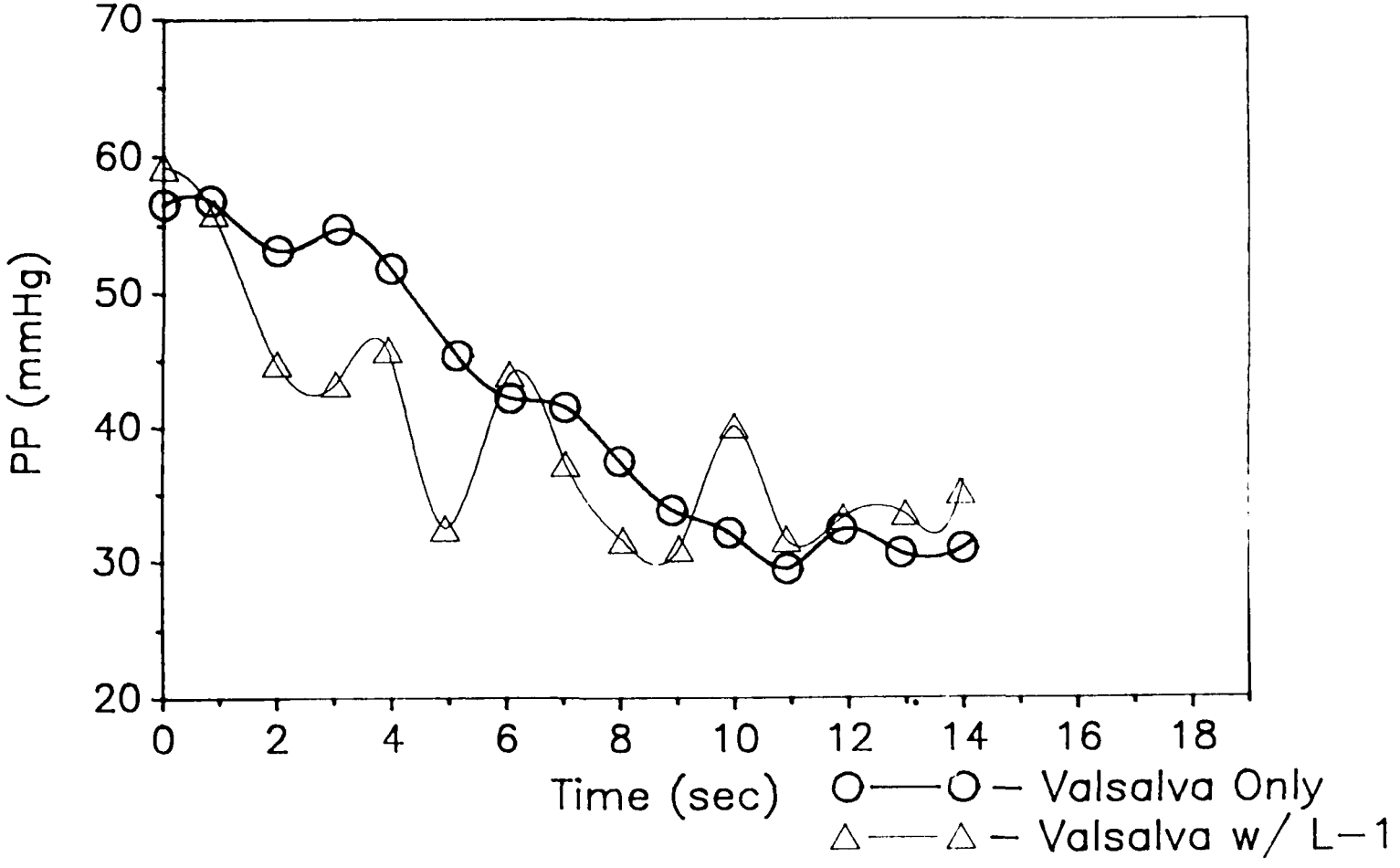
Pulse Pressures

During Straining Manuevers with breathing



Pulse Pressures

During Straining Manuevers with breathing



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APOLIPOPROTEIN COMPARISON STUDY AND CAD PREDICTION STUDY

CHRISTOPHER M. HUDSON

DR. ROBERT A. BRIGHT, MENTOR

CLINICAL PATHOLOGY AND LIPID EVALUATION LABORATORIES

UNITED STATES AIR FORCE SCHOOL OF AEROSPACE MEDICINE

BROOKS AIR FORCE BASE, TEXAS

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PURPOSE

THE PURPOSE OF MY PROJECT IS TWO FOLD. THE FIRST PART CONSISTS OF A COMPARISON OF TESTING METHODS BETWEEN TWO DIFFERENT MACHINES THAT USE DIFFERENT PROCEDURES TO DETERMINE THE CONCENTRATION OF A PARTICULAR SUBSTANCE IN THE BLOOD. THESE SUBSTANCES BEING TESTED FOR ARE CALLED APOLIPOPROTEINS. THEY ARE THE PROTEINS FOUND IN LIPIDS, WHICH ARE FOUND IN THE SERUM PORTION OF THE BLOOD. THE IMPORTANCE IN CALCULATING THESE APOLIPOPROTEIN VALUES IS THAT RECENT STUDIES HAVE SHOWN THEM TO BE ACCURATE PREDICTORS OF CORONARY ARTERY DISEASE AND ARTERIOSCLEROSIS, WHICH BOTH CAUSE HARDENING OF THE ARTERIES AND LEAD TO SERIOUS HEALTH PROBLEMS, INCLUDING DEATH.

THE TWO MACHINES EQUIPPED TO TEST BLOOD SERUM FOR APOLIPOPROTEIN QUANTITIES ARE THE CIBA-CORNING 550 EXPRESS, FOUND HERE AT BROOKS AIR FORCE BASE, AND THE BECKMAN ARRAY FOUND AT WILFORD HALL MEDICAL CENTER ON LACKLAND AIR FORCE BASE. BY RUNNING THE SAME SAMPLES OF BLOOD SERUM ON BOTH MACHINES TO TEST FOR APOLIPOPROTEINS A-1 AND B, (APO A-1, APO B) WE WILL BE ABLE TO COMPARE THE RESULTS TO SEE IF OUR MACHINE OBTAINS THE SAME VALUES AS WHMC. THE REASON THIS PARALLEL TESTING WAS STARTED IS TO CUT DOWN ON EXPENSES FOR THE USAF. THE RECENT NECESSITY FOR APOLIPOPROTEIN VALUES CREATED THE CHORE OF COMMUTING TO WHMC AT LAFB TO RUN OUR APO TESTS BECAUSE OF THE INABILITY TO RUN THESE TESTS ON OUR

OWN MACHINES. HOWEVER, WITH THE INTRODUCTION OF KITS THAT ENABLE US TO RUN THESE TESTS ON OUR OWN MACHINE AT A SIGNIFICANTLY LOWER PRICE, WE DEEMED IT WORTHWHILE TO DO A COMPARISON STUDY TO DETERMINE IF THE VALUES ON OUR MACHINE WERE CONSISTENT WITH THE VALUES OBTAINED FROM THE BECKMAN ARRAY AT WHMC. THEREFORE, IT OUR VALUES PROVE TO BE AS ACCURATE AS THE VALUES RECEIVED FROM WHMC, WE CAN EFFECTIVELY CUT OUT THE COSTS OF TRAVELING TO WHMC AS WELL AS THE EXTRA FUNDS NECESSARY TO RUN THE TESTS ON THE BECKMAN ARRAY, WHICH IS A MORE EXPENSIVE PROCEDURE.

THE SECOND PURPOSE OF MY PROJECT COINCIDES WITH THE FIRST IN THE ASPECT THAT THE STATISTICS GATHERED FROM THE SECOND PART OF MY STUDY WILL ALSO BE USED TO HELP DRAW SOME CONCLUSIONS ON CORONARY ARTERY DISEASE (CAD). WITH THE GREAT IMPORTANCE PLACED ON CHOLESTEROL LEVELS TODAY IN RELATION TO A PERSON'S HEALTH, I DECIDED TO CREATE SOME GRAPHS COMPARING VARIOUS SUBSTANCES FOUND IN THE BLOOD SERUM THAT ARE RELATED TO CAD. I WILL TRY TO DETERMINE IF ANY RELATIONSHIPS EXIST AMONG THE LIPIDS, LIPOPROTEINS, AND APOLIPOPROTEINS. THE IMPORTANCE OF DETERMINING THESE RELATIONSHIPS IS TO DISCOVER WHETHER OR NOT THERE IS A BETTER AND MORE ACCURATE WAY OF PREDICTING CAD, OR ANOTHER FACTOR THAT COULD BE CONSIDERED WHEN TRYING TO PREDICT THE RISK OF CAD. PERHAPS BY COMBINING INFORMATION FOUND THROUGH MY RESEARCH WITH CURRENT METHODS, WE CAN COME UP WITH THE BEST METHOD OF PREDICTING CAD TO EVER BE MADE AVAILABLE.

PERTINENCE

IN TODAY'S AIR FORCE, TECHNOLOGICAL ADVANCES HAVE INCREASED THE PHYSICAL DEMANDS ON FLYER'S BODIES. TO MEET THIS GROWING NEED FOR INCREASED PHYSICAL STAMINA, THE FLYING MEMBERS OF THE AIR FORCE MUST BE IN TOP CONDITION. WHENEVER A FLYER IS GROUNDED FOR ANY REASON, MANY TESTS ARE RUN TO DETERMINE THE STATE OF HIS OR HER HEALTH. SOME OF THE MOST IMPORTANT TESTS ARE DONE ON THE PILOT'S BLOOD TO INSURE A HIGH LEVEL OF WELLNESS. THE CIRCULATORY SYSTEM AND THE HEART MUSCLE PLAY A LARGE ROLE IN A PILOT'S ABILITY TO FLY EFFECTIVELY. WITH SOME PLANES PULLING IN EXCESS OF 9 G'S, THE HEART AND BLOOD VESSELS MUST BE CLEAR OF ALL BUILDUP IF THE BODY IS TO FUNCTION PROPERLY. THE LEADING CAUSE OF THIS BUILDUP IS CHOLESTEROL. TO UNDERSTAND HOW DETRIMENTAL THIS BUILDUP IS, IT IS NECESSARY TO KNOW WHAT HAPPENS TO A PERSON WHEN G-FORCES ARE EXERTED UPON THEIR BODY. G-FORCES ACTING UPON THE BODY CREATE INTENSE PHYSICAL STRAIN. THE PRESSURE BROUGHT ON BY EXCESSIVE G-FORCES CAUSE BLOOD TO POOL IN THE LOWER EXTREMITIES. WHEN THE BLOOD IS GATHERED IN THE LEGS AND TRUNK, NOT ENOUGH OXYGEN REACHES THE BRAIN AND THE PILOT SUBSEQUENTLY BLACKS OUT. ONE WAY TO PREVENT FAINTING IS TO WEAR AN ANTI-G SUIT WHICH FILLS WITH AIR AND PRESSES AGAINST THE LEGS AND TRUNK TO ASSIST THE BLOOD FLOW BACK TO THE HEART. THERE ARE ALSO EXERCISES A PILOT CAN DO WHILE PULLING G'S THAT TIGHTEN HIS MUSCLES AND SEND THE BLOOD FLOWING BACK TO THE HEART. HOWEVER, BOTH OF THESE ACTIONS

WOULD BE INEFFECTUAL IF THE ARTERIES WERE CLOGGED WITH CHOLESTEROL, WHICH IS ALSO REFERRED TO AS ARTERIOSCLEROSIS. NOT ONLY IS THE BRAIN, HEART, AND CIRCULATORY SYSTEM AFFECTED. ALL INTERNAL ORGANS ARE ALSO UNDER EXTREME STRESS DURING A PERIOD OF G-FORCES. FOR THESE REASONS, IT IS EASY TO UNDERSTAND WHY TESTING IS DONE TO DETERMINE IF A PERSON IS AT RISK FOR DEVELOPING CAD.

THE AIR FORCE IS NOT ONLY CONCERNED FOR THE HEALTH OF THEIR FLYERS, BUT ALSO FOR THE HEALTH OF ALL THEIR PERSONNEL. WITH CAD BEING THE NUMBER ONE CAUSE OF DEATH IN WESTERN SOCIETY, THE AIR FORCE IS INTERESTED IN THE HEALTH OF ALL THOSE WHO PROUDLY WEAR THE UNIFORM. IF AN INEXPENSIVE AND RELIABLE METHOD FOR DETERMINING CAD SUSCEPTIBILITY CAN BE FOUND AND UTILIZED, PREVENTIVE CORONARY CARE CAN BE PRACTICED BY AIR FORCE PHYSICIANS TO LOWER THE NUMBERS OF DEATH DUE TO CAD. THEREFORE, THIS RESEARCH IS FUNDAMENTAL IN MAINTAINING THE HEALTH AND STRENGTH OF TODAY'S AIR FORCE.

BACKGROUND

THE PORTION OF THE βLOOD WE USE FOR OUR TESTING IS CALLED THE SERUM. SERUM IS THE LIQUID PORTION OF THE BLOOD THAT IS LEFT WHEN BLOOD IS ALLOWED TO CLOT NATURALLY AND THE CENTRIFUGED TO REMOVE THE BLOOD CELLS AND THE CLOTTING ELEMENTS. SERUM IS A YELLOW COLOR AND CONTAINS PROTEINS, HORMONES, ANTIBODIES, ENZYMES, AND SOME ORGANIC MATERIALS SUCH AS AMINO ACIDS, GLUCOSE, AND FATS. ALSO FOUND IN SERUM ARE INORGANIC ELEMENTS, WASTE MATTER, AND TRACES OF DISSOLVED OXYGEN AND CARBON DIOXIDE. HOWEVER, THE COMPONENTS WE ARE MOST INTERESTED IN ARE THE LIPIDS, LIPOPROTEINS, AND APOLIPOPROTEINS. THE LIPIDS ARE TRIGLYCERIDES, CHOLESTEROL, AND PHOSPHOLIPIDS. THE FOUR LIPOPROTEINS ARE: HIGH DENSITY LIPOPROTEINS, LOW DENSITY LIPOPROTEINS, INTERMEDIATE LIPOPROTEINS, AND VERY LOW DENSITY LIPOPROTEINS. (ABBREVIATED HDL, LDL, IDL, AND VLDL) THE APOLIPOPROTEINS ARE APO'S A-1, B, C, AND E. A LIPOPROTEIN IS A COMBINATION OF LIPIDS AND APOLIPOPROTEINS. TO UNDERSTAND HOW ALL OF THESE SERUM COMPONENTS INTERACT, ONE MUST FIRST REALIZE ONE IMPORTANT CONCEPT. IN A NORMAL, HEALTHY INDIVIDUAL, A CYCLE TAKES PLACE CONTINUOUSLY IN DIFFERENT STAGES THROUGHOUT THE BODY AND ALL OF THE BODY'S CELLS INTERACT WITH THE BLOOD'S COMPONENTS. THE REACTIONS AND CHANGES IN THIS CYCLE TAKE PLACE SIMULTANEOUSLY AND THE BODY ALWAYS REMAINS IN EQUILIBRIUM. PROBLEMS OCCUR WHEN THIS EQUILIBRIUM IS LOST.

THIS CYCLE STARTS IN THE SMALL INTESTINE.. WHEN FOOD REACHES THE SMALL INTESTINE, TRIGLYCERIDES AND CHOLESTEROL FROM THE FOOD ARE ABSORBED THROUGH THE INTESTINAL WALL AND COMBINE WITH OTHER CONSTITUENTS TO FORM VLDL. THE VLDL ARE MAKE IN THE LIVER AND THE INTESTINE AND ARE THE LARGEST AND LEAST DENSE OF THE LIPOPROTEINS. 90% OF THEIR PARTICLE MASS IS COMPOSED OF LIPIDS, WITH 60% OF THAT BEING TRIGLYCERIDE, AND THE REMAINING 40% BEING EQUALLY DIVIDED BETWEEN CHOLESTEROL AND PHOSPHOLIPIDS. THE REMAINING 10% OF THE PARTICLE MASS IS PROTEINS, INCLUDING APO'S A-1, B, C, AND E. TRIGLYCERIDES (TRIGS) ARE BASICALLY FATS FOUND IN THE FOODS WE EAT. THE CHOLESTEROL AND TRIGS LEAVE THE INTESTINAL CELLS AS VLDL AND ENTER THE LYMPHATIC SYSTEM. THIS VLDL THEN ENTERS THE CIRCULATION THROUGH THE THORACIC DUCT.

THE VLDL SERVES AS A TRANSPORT FOR TRIGS. THE VLDL TAKES THE TRIGS TO THE ADIPOSE TISSUES OF THE BODY, WHICH ARE FAT STORAGE SITES. THESE TISSUES ARE LOCATED PRIMARILY IN THE TRUNK AND LEGS. THE TRIGS ARE DROPPED OFF AND STORED FOR LATER USE AS ENERGY WHEN THE BODY NEEDS IT. AFTER DROPPING OFF THE TRIGS, THERE ARE SEVERAL THINGS THAT CAN HAPPEN TO THE VLDL. APPROXIMATELY ONE-THIRD OF THE VLDL REMNANTS RETURN TO THE LIVER WHERE THEY ARE REMODELED INTO LDL. THE REST UNDER GO CHANGES IN THE BLOOD WHERE THEIR REMAINS ARE CONVERTED INTO IDL. IDL IS BASICALLY VLDL WITHOUT THE TRIG.

IDL IS CONVERTED INTO LDL AFTER TRANSFERRING SOME ITS COMPONENTS TO HDL IN THE BLOODSTREAM. IDL IS ONLY A STEP BETWEEN VLDL AND LDL. IDL IS THEREFORE MADE UP OF A SMALL AMOUNT OF TRIG THAT WAS NOT DISTRIBUTED TO THE ADIPOSE CELLS, CHOLESTEROL, PHOSPHOLIPIDS, AND APOLIPOPROTEINS A-1, B, C, AND E. HDL RECEIVES, FROM THE IDL, APO A-1 AND SOME OF APO'S C AND E, AND SOME TRIG, CHOLESTEROL, AND PHOSPHOLIPIDS. THE REMAINDER OF THESE GLOBULES ARE LDL AND CONTAIN THE MAJORITY OF THE CHOLESTEROL, ALL THE APO B, SOME TRIG AND PHOSPHOLIPIDS, AND A LITTLE OF APO'S C AND E. LDL FOLLOWS VLDL IN INCREASING DENSITY AND DECREASING SIZE. THE LACK OF EXCESSIVE AMOUNTS OF TRIG IS RESPONSIBLE FOR THIS. 75% OF THE PARTICLE MASS IN LDL IS LIPIDS, WITH 60% BEING CHOLESTEROL, 30% BEING PHOSPHOLIPIDS, AND 10% BEING TRIG. THE 25% PARTICLE MASS REMAINING IS PROTEIN, WITH APO B COMPRISING THE MAJORITY OF THAT PERCENTAGE, ALONG WITH A SMALL AMOUNT OF APO'S C AND E.

THE LDL IS PRODUCED IN THE LIVER, AS WELL AS BY THE PROCESS DESCRIBED THAT OCCURS IN THE BLOOD. LDL IS A CHOLESTEROL TRANSPORT VEHICLE. THE BODY PRODUCES ENOUGH CHOLESTEROL BY ITSELF TO SUSTAIN ALL OF THE BODY'S NEEDS. WHEN EXCESSIVE AMOUNTS ARE INTRODUCED INTO THE BODY THROUGH THE FOODS WE EAT, THE BODY MUST FIND A WAY TO GET RID OF IT. CHOLESTEROL IS THOUGHT TO BE IMPORTANT IN MAINTAINING THE CELL MEMBRANES NECESSARY FOR CELL HEALTH. LDL TRANSPORTS THE CHOLESTEROL TO THE CELLS AND IS RECEIVED BY THE LDL

RECEPTORS. THE ENTIRE LDL GLOBULE IS ENGULFED BY THE PERIPHERAL CELL AND BROKEN DOWN. THE CHOLESTEROL IS THEN ESTERFIED, OR CHEMICALLY ATTACHED TO A FATTY ACID. THE APOLIPOPROTEINS ARE BROKEN DOWN INTO AMINO ACIDS AND THE REMAINDER OF THE LDL COMPONENTS ARE SYNTHESIZED INTO A FORM USABLE BY THE CELL. ONCE THE CELL HAS ALL THE CHOLESTEROL IT REQUIRES, IT BEGINS TO EXPORT THE CHOLESTEROL VIA ITS FREE FORM WHICH IS PICKED UP FROM THE CELL BY THE HDL.

THE NEXT AND FINAL LIPOPROTEIN IN THIS CYCLE IS HDL. NASCENT HDL IS MADE IN THE LIVER AND PICKS UP VARIOUS LIPIDS AND PROTEINS IN THE BLOOD BY TRANSFERS FROM VLDL AND IDL. HDL IS THE SMALLEST AND MOST DENSE OF THE LIPOPROTEINS. ITS PARTICLE MASS IS EQUALLY DIVIDED AMONG LIPIDS AND PROTEINS. THE LIPID HALF IS 50% PHOSPHOLIPIDS, 32% CHOLESTEROL, AND 10% TRIG. IN THE PROTEIN HALF, THE MAJOR APOLIPOPROTEIN IS A-1, WITH A MINOR APO C AND APO E CONTENT. HDL PLAYS A VERY IMPORTANT ROLE IN THIS CYCLE. IN PERIPHERAL CELLS, THE CONTINUING CYCLE OF BREAKING DOWN LDL IS BALANCED BY THE EXPORT OF CHOLESTEROL TO THE OUTER WALL THE OF THE CELL TO BE PICKED UP BY HDL AT THE HDL RECEPTOR. THE HDL PICKS UP THE CHOLESTEROL AND PASSES SOME TO THE LDL WITHIN THE BLOOD, AND TAKES THE REST TO THE LIVER. THERE THE CHOLESTEROL CAN BE METABOLIZED AND EXCRETED THROUGH THE BILE INTO THE INTESTINE OR BE REABSORBED AND ENTER BACK INTO THE CYCLE.

THE TWO APOLIPOPROTEINS WE ARE MAINLY CONCERNED WITH ARE APO A-1 AND APO B. APO B COMPRISES THE GREAT MAJORITY OF THE APOLIPOPROTEIN PERCENTAGE OF LDL. THE REASON WE TEST FOR APO B ALONG WITH CALCULATING LDL IS THAT APO B GIVES US ANOTHER METHOD OF READING THE AMOUNT OF CHOLESTEROL THAT THE LDL IS CARRYING THROUGH THE BODY. APO B IS A CHOLESTEROL CARRIER AND DETERMINES THE SIZE OF THE LOAD OF CHOLESTEROL THAT LDL CAN DISPERSE TO THE PERIPHERAL TISSUES. THE TASK OF APO A-1 IS NOT AS CLEAR AS THAT OF APO B, BUT THE SIGNIFICANCE IS JUST AS GREAT. APO A-1 IS BELIEVED TO BE IMPORTANT AS AN ENZYME ACTIVATOR. APO A-1 ACTIVATES THE LECITHIN CHOLESTEROL ACYL TRANSFERASE (LCAT) ENZYME THAT IS THOUGHT TO BE RESPONSIBLE FOR ESTERFYING CHOLESTEROL FROM ITS FREE FORM. FREE CHOLESTEROL IS THE ACTIVE FORM OF CHOLESTEROL. IT IS USED IN CONJUNCTION WITH THE PRODUCTION OF HORMONES IN THE TESTES AND THE ADRENAL GLANDS. ESTERFIED CHOLESTEROL IS THE STORAGE FORM OF CHOLESTEROL. ESTERFIED CHOLESTEROL IS A STORAGE FORM OF CHOLESTEROL THAT IS FOUND AT THE CORE OF A LIPOPROTEIN GLOBULE. IN ITS ESTERFIED FORM, CHOLESTEROL CAN BE SAFELY TRANSPORTED TO THE LIVER TO BE METABOLIZED. FREE CHOLESTEROL IS THOUGHT TO BE BAD IF THERE IS TOO MUCH BECAUSE ITS BUILD UP IN PERIPHERAL CELLS CAN STOP THE CELL FROM ACCEPTING ANY MORE LDL. WHEN THE CELL QUITS ACCEPTING LDL, THERE BECOMES AN OVERLOAD OF LDL IN THE BLOOD AND THERE ARE NOT ENOUGH HDL TO PICK UP THE CHOLESTEROL TO ALLOW THE CYCLE TO CONTINUE FUNCTIONING. THIS LINGERING OF CHOLESTEROL IN THE CELLS SOON BECOMES

TOXIC TO THE CELL AND KILLS IT. APO A-1 IS IMPORTANT BECAUSE IT ACTIVATES THE LCAT ENZYME WHICH ESTERFIES THE CHOLESTEROL SO IT CAN BE TRANSPORTED TO THE LIVER AND THE CYCLE CAN BE CONTINUED. THE OXIDATION OF CHOLESTEROL WITHIN THE CELLS AND WITHIN THE LDL GLOBULES OF THE BLOOD IS WHAT CAUSES THE TOXICITY. WHEN THE CELLS OF THE ARTERY WALLS ARE KILLED BY OXIDIZED CHOLESTEROL, A CREVICE IS FORMED IN THE WALL AND DEBRIS IS CREATED. WHEN THE LEUKOCYTE (WHITE CELL) SCAVENGERS, OR MACROPHAGES, COME TO REMOVE THE DEBRIS, THE ARE KILLED ALSO. THIS CREATES A SPOT FOR THE BUILD UP OF CHOLESTEROL. APO B IS RESPONSIBLE FOR DETERMINING WHERE ITS CHOLESTEROL LOAD IS DROPPED OFF. WHEN THERE IS AN EXCESS OF LDL IN THE BLOOD, THE APO B AND ITS LIPIDS WILL ACCUMULATE AT ONE OF THE SITES DESTROYED BY OXIDIZED CHOLESTEROL, AND A BUILD UP IS STARTED. THE REST OF THE LDL, THE PROTEIN PORTION, IS METABOLIZED OR WASHED AWAY BY THE SERUM, BUT THE INSOLUBLE LIPID PORTION REMAINS ATTACHED TO THE ARTERY WALL, CAUSING BLOCKAGE.

BY THIS TIME, ESTERFIED CHOLESTEROL IS JUST AS BAD AS FREE CHOLESTEROL BECAUSE IT TOO WILL STICK TO THE BUILD UP. FOR THESE REASONS, WE MEASURE TOTAL CHOLESTEROL. TOTAL CHOLESTEROL IS THE COMBINATION OF ALL THE FREE AND ESTERFIED CHOLESTEROL FOUND IN THE BLOOD SERUM. IF THE TOTAL CHOLESTEROL IS HIGH, WE CAN PREDICT THAT THERE WILL BE A CHANCE FOR CORONARY ARTERY DISEASE, OR CAD. (SEE CHART, NEXT PAGE) CAD IS THE DETERIORATION OF ARTERY WALLS AND THE BUILD

UP THAT OCCURS THERE. HDL IS NEEDED TO PICK UP THE FREE CHOLESTEROL AND TRANSFER IT TO LDL OR ESTERFY IT AND TRANSPORT IT TO THE LIVER IF THE BODY'S CYCLE IS TO STAY IN EQUILIBRIUM. THIS IS WHY THE TOTAL CHOLESTEROL/HDL CHOLESTEROL RATIO (TC/HDL CHOL RAT.) WAS DEVELOPED. THE LOWER THE RATIO, THE LESS CHANCE FOR CAD. HIGH RISK FOR CAD IS CONSIDERED ANYTHING HIGHER THAN A RATIO OF 6.0.

NATIONAL INSTITUTES OF HEALTH CRITERIA FOR
EVALUATING TOTAL CHOLESTEROL LEVELS

PATIENT AGE	MODERATE RISK	HIGH RISK
20 - 29	OVER 200 MG/DL	OVER 220 MG/DL
30 - 39	OVER 220 MG/DL	OVER 240 MG/DL
40+	OVER 240 MG/DL	OVER 260 MG/DL

THERE ARE OTHER FACTORS THAT ARE ALSO RELATED TO A PERSON'S RISK OF CAD. WHEN A PERSON HAS AN EXCESSIVE AMOUNT OF TRIGS, (OVER 210 MG/DL ACCORDING TO THE NORMAL RANGES USED IN THE CLINICAL PATHOLOGY LAB AT BAFB) THEY ARE APT TO HAVE AN OVER ABUNDANCE OF VLDL. WITH AN INCREASE IN VLDL, THERE IS A LACK OF SUFFICIENT AMOUNTS OF APO'S A-1, C, AND E NECESSARY TO CREATE ENOUGH HDL'S TO KEEP THE SYSTEM IN EQUILIBRIUM. THEN AFTER THE VLDL DISTRIBUTES ITS TRIG LOAD TO THE ADIPOSE CELLS, THE SUBSEQUENT BREAKDOWN OF VLDL INTO IDL AND THEN LDL CREATES AN OVERLOAD OF LDL. THE DANGER OF TOO MANY LDL'S HAS ALREADY BEEN EXPLAINED, AS WELL AS THE PROBLEMS ASSOCIATED WITH TOO MUCH CHOLESTEROL IN EITHER FORM, ESTERFIED OR FREE.

THE APO A-1 TO APO B RATIO (A-1/B RATIO) IS ALSO IMPORTANT IN PREDICTING THE RISK OF CAD. WITH THE SIGNIFICANCES OF BOTH APO'S MENTIONED, IT IS IMPORTANT TO COMPREHEND THE MEANING OF THE RATIO OF THE TWO. THIS RATIO IS INVERSELY RELATED TO THE TOTAL CHOLESTEROL/HDL CHOL. RATIO. IN THE A-1/B RATIO, THE GREATER THE RATIO, THE LESS CHANCE THERE IS OF DEVELOPING CAD.(SEE CHART BELOW). THIS RATIO COMPARES THE AMOUNT OF A-1 AVAILABLE TO ESTERFY CHOLESTEROL AND REMOVE IT FROM THE CYCLE TO THE AMOUNT OF CHOLESTEROL THAT LDL IS ABLE TO CARRY WITH ITS APO B CARRIER TO THE PERIPHERAL TISSUES. AS YOU CAN SEE, THIS RATIO IS ONE OF THE MOST SPECIFIC AND ACCURATE TESTS POSSIBLE FOR PREDICTING THE RISK OF CAD.

THE RISK INDEX IS ANOTHER METHOD BY WHICH TO PREDICT THE RISK OF CAD. THE RISK INDEX IS EXPLAINED LATER IN THIS REPORT IN THE CHART DESCRIPTION AND EXPLANATION SECTION.

CHART FROM SIGMA DIAGNOSTICS APOLIPOPROTEIN TESTING KIT FOR DETERMINING THE RISK OF CAD

RISK OF CAD	RATIO OF A1/B	
	MALE	FEMALE
AVERAGE	1.4	1.6
2 TIMES AVE.	1.1	1.1
3 TIMES AVE.	1.0	1.0

FROM THIS CHART, YOU CAN SEE THAT IT IS IDEAL TO HAVE A RATIO OF 1.4 OR ABOVE FOR MALES AND 1.6 AND ABOVE FOR FEMALES. WITH A RATIO LOWER THAN 1.0, CAD IS ALMOST IMMINENT. THE A-1/B RATIO IS ONE OF THE BEST METHODS AVAILABLE FOR PREDICTING THE RISK OF CORONARY ARTERY DISEASE. BELOW ARE THE STATISTICS FOR NORMAL APO A-1 AND APO B LEVELS AND THE LEVELS AT WHICH CAD HAS BEEN DIAGNOSED. THIS GRAPH IS FROM THE SIGMA DIAGNOSTICS APOLIPOPROTEIN PAMPHLET.

	APO A-1 MG/DL	APO B MG/DL
NORMAL	132 +/- 20	83 +/- 13
DIAGNOSED CAD	98 +/- 15	114 +/- 23

AS SHOWN BY THIS CHART, IT IS BENEFICIAL TO A PERSON'S HEALTH TO HAVE AN APO A-1 VALUE THAT IS HIGH AND AN APO B VALUE THAT IS LOW.

PROCEDURE

AFTER THE BLOOD IS DRAWN FROM THE PATIENTS, WE ARE READY TO BEGIN OUR TESTING. THE TUBES ARE FIRST PLACED IN A CENTRIFUGE AND SPUN AT 2000 RPM FOR 10 MINUTES. THIS DIVIDES THE BLOOD INTO LAYERS BY DENSITY. THE CELLULAR PORTION OF THE BLOOD, CONTAINING THE RED AND WHITE BLOOD CELLS, SETTLES IN THE BOTTOM HALF OF THE TUBE. THE BLOOD SERUM, WHICH IS A CLEAR YELLOW, IS LESS DENSE THAN THE BLOOD CELLS AND FLOATS ON TOP OF THEM IN THE TOP HALF OF THE TUBE. THE SERUM IS THEN ASPIRATED AND SAVED WHILE THE REMAINDER OF THE SAMPLE IS DISCARDED. THE SERUM CONTAINS THE CHOLESTEROL, HDL, AND THE TRIGLYCERIDES THAT WE WILL BE TESTING FOR. THE MACHINE THAT WILL RUN THE TEST FOR TRIGLYCERIDES IS THE SAME MACHINE WE USE TO RUN OUR APOLIPOPROTEIN TESTS ON. THIS MACHINE IS THE CIBA-CORNING 550 EXPRESS.

ON THE 550 EXPRESS, THERE ARE TWO ROUND, ROTATING TRAYS THAT SIT ON A CIRCULAR, HORIZONTAL WHEEL THAT TURNS THE TRAYS AUTOMATICALLY. THE FIRST TRAY IS EQUIPPED TO HOLD SMALL SERUM SAMPLE CUPS. THE SECOND TRAY HOLDS THE REAGENT BOTTLES. FOR EVERY TEST THERE IS A SPECIFIC REAGENT. SOME OF THE OTHER TESTS THAT CAN BE DONE ON THE 550 EXPRESS ON BLOOD SERUM INCLUDE: BILIRUBIN, PROTEIN, CREATININ, URIC ACID, ALBUMIN, PHOSPHOROUS, AND CALCIUM JUST TO NAME A FEW. AS WITH THE TESTS FOR OTHER SUBSTANCES, TRIGLYCERIDES HAVE A

SPECIAL REAGENT OF THEIR OWN. THE REAGENT BOTTLES ARE DISTINGUISHED BY BAR CODES ON THE BOTTLE THAT ARE READ BY THE 550'S ELECTRONIC SCANNER. 500 LAMBDA OR .5 MILLILITERS OF SERUM IS PIPETTED INTO A SERUM SAMPLE CUP FROM EVERY PATIENT'S TUBE OF SERUM. ALONG WITH THE CUPS OF THE PATIENT'S SERUM SAMPLES, THREE CONTROL SAMPLES ARE ALSO PIPETTED INTO SAMPLE CUPS. THE CONTROL SAMPLES HAVE A KNOWN VALUE AND ARE MANUFACTURED BY CIBA-CORNING, THE MAKER OF THE 550 EXPRESS. THESE CONTROLS ARE INCLUDED TO MAKE SURE THAT THE 550 IS ACCURATELY DETERMINING THE TRIGLYCERIDE VALUES.

AFTER SETTING UP THE SERUM SAMPLE CUPS, THE REAGENT BOTTLES SHOULD BE PLACED IN THE REAGENT TRAY WITH THE UPC BAR CODES SHOWING SO THAT THE 550 CAN TELL WHICH REAGENT IS IN WHICH POSITION. THE 550 MUST NOW BE PROGRAMMED TO RUN THE SPECIFIC TESTS THAT WE HAVE SET UP FOR. THE CONTROL SAMPLES ARE GOOD FOR ALL THE DIFFERENT TESTS, SO ONLY ONE SET MUST BE USED. THE TESTS ARE NOW READY TO BE RUN. A NEEDLE ASPIRATES 3 LAMBDA OR 3 MICROLITERS OF THE SAMPLE AND MIXES IT WITH 300 LAMBDA OF THE TRIGYLCERIDE REAGENT IN A CUVETTE, WHICH IS A SMALL, SQUARE, PLASTIC, CONTAINER WITH AN OPEN TOP. THIS MIXTURE IS WARMED TO 37 DEGREES CELSIUS, OR NORMAL BODY TEMPERATURE AND IS ALLOWED TO INCUBATE FOR 8 MINUTES. DURING THIS INCUBATION PERIOD, A SERIES OF ENZYMATIC REACTIONS TAKE PLACE AND THE FINAL PRODUCT IS QUINONEIMINE DYE AND WATER. A LIGHT BEAM IS THEN SHOT

THROUGH THE MIXTURE TO MEASURE THE OPTICAL DENSITY. THE 550 EXPRESS THEN AUTOMATICALLY CONVERTS OPTICAL DENSITY INTO THE AMOUNT OF LIGHT ABSORBANCE AT A WAVELENGTH OF 500 NANOMETERS. THE INCREASE IN THE LIGHT ABSORBANCE FROM THE TIME THE SERUM AND REAGENT WERE FIRST COMBINED UNTIL THE END OF THE 8 MINUTE INCUBATING PERIOD IS DIRECTLY PROPORTIONAL TO THE CONCENTRATION OF TRIGLYCERIDE IN THE SAMPLE. THIS TYPE OF TESTING ON THE 550 EXPRESS IS REFERRED TO AS SPECTROPHOTOMETRY.

THE MACHINE WE USE TO CALCULATE THE TOTAL CHOLESTEROL (TC) AND HDL CHOLESTEROL (HDL CHOL) IS THE ABBOTT VP SERIES II F BICHROMATIC ANALYZER. THE ABBOTT IS SIMILAR TO THE 550 EXPRESS IN THAT THEY BOTH USE SAMPLE CUPS ON A ROTATING TRAY AND MIX THE SAMPLE WITH A SPECIFIC REAGENT IN A CUVETTE. THE ABBOTT, HOWEVER, ONLY HAS ONE TRAY. THERE IS NO REAGENT TRAY. THE ABBOTT USES THE SAME REAGENT FOR BOTH TESTS. A SMALL PIPE RUNS FROM THE REAGENT CONTAINER THROUGH A DEVICE THAT MEASURES OUT 250 LAMBDA OF REAGENT FOR EACH SAMPLE AND THEN CONNECTS TO THE NEEDLE THAT ASPIRATES THE SAMPLE SO THAT THE TWO CAN BE COMBINED IN THE CUVETTE. THE REAGENT USED IN BOTH THE TC AND HDL CHOL TEST IS MANUFACTURED BY BOEHRINGER MANNHEIM DIAGNOSTICS. 300 LAMBDA OF EACH SAMPLE IS PLACED IN THE SAMPLE CUPS ON THE ROTATING TRAY. THE FIRST SAMPLE CUP CONTAINS WATER, WHICH SHOULD READ AS HAVING NO TC OR HDL CHOL. THE MACHINE CALIBRATES ITSELF FROM THIS WATER SAMPLE TO SET THE ZERO POINT. THE NEXT TWO SAMPLE

CUPS CONTAIN STANDARDS MANUFACTURED BY ABBOTT DIAGNOSTICS. THESE STANDARDS HAVE SET VALUES AND ALSO HELP CALIBRATE THE MACHINE. THE VALUES OF THE STANDARDS ARE 100 MG/DL AND 300 MG/DL FOR THE TC TEST AND 25 MG/DL AND 100 MG/DL FOR THE HDL CHOL TEST. THE REASON THE TC STANDARDS ARE HIGHER THAN THE HDL CHOL STANDARDS IS THAT TOTAL CHOLESTEROL INCORPORATES ALL CHOLESTEROL VALUES, INCLUDING HDL CHOLESTEROL VALUES. HDL CHOL TESTS SPECIFICALLY FOR CHOLESTEROL ONLY FOUND IN HDL. THESE STANDARDS CORRESPOND WITH THE NORMAL RANGE OF THE SUBSTANCES BEING TESTED. MOST TC VALUES ARE BETWEEN 100 AND 300 MG/DL WHILE MOST HDL CHOL VALUES ARE BETWEEN 25 AND 100 MG/DL. THERE ARE ALSO 3 CONTROLS THAT ARE RUN IN BOTH THE TC AND HDL CHOL TESTS. THESE CONTROLS HAVE KNOWN VALUES AND ARE USED TO DETERMINE IF THE ABBOTT IS OPERATING PROPERLY AND IS COMING UP WITH LEGITIMATE TC AND HDL CHOL VALUES. IF THE MACHINE READ VALUE IS THE SAME AS THE KNOWN VALUE FOR THE CONTROL, THEN WE KNOW THAT THE MACHINE IS OPERATING PROPERLY. THE CONTROLS FOR BOTH TC AND HDL CHOL ARE MANUFACTURED BY CIBA-CORNING DIAGNOSTICS.

IN BOTH TESTS, 5 LAMBDA OF SERUM SAMPLE IS COMBINED WITH THE 250 LAMBDA OF REAGENT IN A CUVETTE. THE MIXTURE IS HEATED TO 37 DEGREES AND ALLOWED TO INCUBATE FOR 6 MINUTES. DURING THIS INCUBATION, ALL OF THE CHOLESTEROL ESTERS ARE HYDROLYZED BY A PROCESS CALLED MICROBIAL CHOLESTEROL ESTERAGE. AS IN THE TEST FOR TRIGLYCERIDES, QUINONEIMINE DYE AND WATER ARE PRODUCED. THEN THE CHANGE IN THE AMOUNT

OF LIGHT ABSORBANCE AT A WAVELENGTH OF 500 NANOMETERS IS DETERMINED TO CALCULATE THE CONCENTRATION OF TC OR HDL CHOL IN THE SAMPLE. THE LESS LIGHT THAT CAN PASS THROUGH, THE GREATER THE ABSORBANCE AND THE HIGHER THE TC OR HDL CHOL CONCENTRATION IS. THE INTENSITY OF THE PURPLE COLOR FORMED IS PROPORTIONAL TO THE TC OR HDL CHOL CONCENTRATION AND CAN BE CALCULATED BY THIS FORMULA.

$$\frac{\text{CONCENTRATION OF STANDARD}}{\text{ABSORBANCE OF STANDARD}} \times \text{ABSORBANCE OF SPECIMEN} = \text{MG/DL OF TC OR HDL CHOL}$$

THE TESTING PROCEDURE FOR TC AND HDL CHOL IS EXACTLY THE SAME, EXCEPT FOR A FEW SMALL DETAILS, SUCH AS THE VALUES OF THE STANDARDS AND THE CONTROLS ARE DIFFERENT. THE MAIN DIFFERENCE BETWEEN THE TWO TESTS IS IN THE MANNER IN WHICH THE SAMPLES WERE PREPARED FOR TESTING. TO PREPARE FOR A TC TEST ON THE ABBOTT, YOU JUST PLACE THE PROPERLY MEASURED PORTION OF THE SERUM IN THE SAMPLE CUPS. HOWEVER, TO RUN THE HDL CHOL TEST ON THE ABBOTT, THEIR IS A NECESSARY PREPARATORY PROCESS. 500 LAMBDA OF SERUM TO BE USED FOR THE HDL CHOL TEST IS PIPETTED INTO A SMALL CONE-SHAPED REAGENT TUBE THAT CONTAINS A PRE-MEASURED AMOUNT OF REAGENT. THIS REAGENT IS DEXTRAN SULFATE MAGNESIUM REAGENT WITH A MOLECULAR WEIGHT OF 50,000. THESE REAGENT TUBES ARE MANUFACTURED BY CANYON DIAGNOSTICS. THIS REAGENT PRECIPITATES EVERYTHING BUT THE HDL CHOLESTEROL FROM THE SERUM SAMPLE. SOME OF THE SUBSTANCES PRECIPITATED INCLUDE:

LDL, VLDL, TRIGLYCERIDE, AND VARIOUS OTHER MICRONS THAT COULD PERHAPS INTERFERE WITH THE HDL CHOL READING. THE REAGENT TUBE IS THEN CAPPED AND MIXED FOR 30 SECONDS. YOU MUST LET THE TUBES SIT FOR FIVE MINUTES SO THE PRECIPITATION REACTION HAS TIME TO OCCUR. THE TUBES ARE THEN CENTRIFUGED AT 1500 RPM FOR 10 MINUTES TO ALLOW THE PRECIPITATES TO SETTLE IN THE BOTTOM. THE PRECIPITATE FORMS A PELLET IN THE BOTTOM OF THE TUBE AND THE SUPERNATANT FLUID IS ASPIRATED OFF THE TOP. THIS LIQUID IS THEN PLACED IN THE SERUM SAMPLE CUPS JUST LIKE THE SERUM FOR THE TC TEST, EXCEPT THIS SAMPLE CONTAINS ONLY HDL CHOLESTEROL. FROM HERE ON OUT, THE TEST IS THE SAME AS DESCRIBED EARLIER.

THE TESTS FOR APOLIPOPROTEINS A-1 AND B HERE AT BROOKS AIR FORCE BASE ARE QUITE SIMILAR TO THE METHODS USED TO TEST FOR TRIGLYCERIDES. THE APO A-1 AND APO B TESTS ARE ALSO DONE ON THE 550 EXPRESS. THERE IS A SPECIAL REAGENT FOR BOTH, AS WELL AS SERUM CONTROLS AND CALIBRATORS. ALL OF THESE SUBSTANCES ARE PART OF THE RAICHEM APO TESTING KIT, MANUFACTURED BY REAGENTS APPLICATIONS, INC.. THE PROCESS FOR OBTAINING AND PREPARING THE SERUM IS THE SAME AS FOR THE TRIG TEST. THEN 500 LAMBDA OF SERUM IS PLACED IN THE SAMPLE CUP AND THE REAGENTS ARE PLACED ON THE REAGENT WHEEL. 3 LAMBDA OF SERUM IS COMBINED WITH 300 LAMBDA OF REAGENT IN BOTH THE A-1 AND THE B TEST. THE MIXTURES ARE PLACED IN A CUVETTE AND ALLOWED TO INCUBATE AT NORMAL BODY TEMPERATURE OF 37 DEGREES CELSIUS. THE APO A-1 INCUBATES FOR TEN

MINUTES, WHILE THE APO B ONLY INCUBATES FOR 5. DURING THIS TIME, A SERIES OF TURBIDIMETRIC REACTIONS TAKE PLACE THAT PRODUCE THE QUINONEIMINE DYE. THE WAVELENGTH USED FOR APO'S A-1 AND B IS 340 NANOMETERS. THE 550'S COMPUTER GOES THROUGH A SERIES OF CALCULATIONS TO ARRIVE AT THE CONCENTRATION OF APO A-1 AND APO B. THE STEPS IN THIS SERIES OF CALCULATIONS ARE AS FOLLOWS: THE % TRANSMITTANCE IS DETERMINED BY USING A SPECIFIC WAVELENGTH(340NM) FROM WHICH THE OPTICAL DENSITY IS CALCULATED, WHICH, IN TURN, IS USED TO DETERMINE THE AMOUNT OF CHANGE IN LIGHT ABSORBANCE . FROM THIS INFORMATION, THE APO VALUES CAN BE CALCULATED. THEREFORE, THE MORE LIGHT THAT IS ABLE TO PASS THROUGH THE CUVETTE, THE LESS THE ABSORBANCE AND THE LOWER THE CONCENTRATION OF APO A-1 OR APO B.

THE TESTS FOR APOLIPOPROTEINS AT WILFORD HALL MEDICAL CENTER AT LAFB ARE VERY SIMILAR TO THE TESTS WE RUN HERE. THE MAIN DIFFERENCE IS IN THE METHOD THE MACHINE USES TO CALCULATE THE CONCENTRATION OF THE APO A-1 AND APO B. ON THE BECKMAN ARRAY MACHINE AT WHMC, SERUM IS PIPETTED INTO THE SERUM SAMPLE CUPS THAT ARE PLACED ON ONE TRAY AND THE REAGENTS ARE PLACED ON ANOTHER. A NEEDLE COMBINES THE TWO IN A CUVETTE AND THEY ARE ALLOWED TO INCUBATE AT NORMAL BODY TEMPERATURE FOR A SET TIME. HOWEVER, WHAT HAPPENS DURING THIS INCUBATION PERIOD IS WHAT MAKES THESE TWO MACHINES VERY DIFFERENT. THE 550 EXPRESS HERE AT BAFB USES SPECTROPHOTOMETRY TO MEASURE THE CHANGE IN LIGHT ABSORBANCE

AT A SPECIFIC WAVELENGTH. ON THE BECKMAN ARRAY, THE PROCEDURE THAT IS USED IS CALLED NEPHELOMETRY. SPECIAL REAGENTS ARE USED ON THIS PROCESS THAT ARE DIFFERENT FROM THE APO REAGENTS USED WITH THE 550 EXPRESS. WHEN THESE REAGENTS COMBINE WITH THE SERUM SAMPLE, NO COLOR CHANGE TAKES PLACE. INSTEAD, THE REAGENT COMBINES WITH THE APOLIPOPROTEINS IN THE SERUM AND FORMS A SOLID. THE BECKMAN ARRAY THEN SHOOTS A BEAM OF LIGHT THROUGH THE AQUEOUS MEDIUM IN CUVETTE AND MEASURES THE SCATTERING, OR DEFLECTION, OF THE LIGHT AND IS ABLE TO DETERMINE AN APO VALUE.

APOLIPOPROTEIN COMPARISON STUDY CHART EXPLANATIONS

THE CHART IMMEDIATELY FOLLOWING THIS PAGE CONTAINS ALL THE DATA FOR THE COMPARISON STUDY BETWEEN BROOKS AFB APO TESTING METHODS AND THE LACKLAND AFB APO TESTING METHODS. AFTER RUNNING THE SAME SAMPLES ON BOTH MACHINES, THESE RESULTS WERE COMPILED. PRINTOUTS WITH THE RESULTS FROM THE BECKMAN ARRAY AT WHMC FROM LAFB ARE LOCATED IN THE PRINTOUT SECTION. RESULTS FROM THE CIBA-CORNING 550 EXPRESS AT BAFB WERE RECORDED DIRECTLY FROM THE 550 EXPRESS' MONITOR TO THE COMPUTER DATA FILES. THIS CHART IDENTIFIES THE PATIENT BY A CASE NUMBER, LOCATED UNDER THE COLUMN HEADING "CASENR". THE NEXT THREE COLUMNS CONTAIN THE APO A-1, APO B, AND A-1/B RATIO FROM WILFORD HALL, RESPECTIVELY. THE NEXT THREE COLUMNS CONTAIN THE SAME INFORMATION AS THE PREVIOUS THREE, EXCEPT THE VALUES ARE FROM BROOKS AFB.

THE AVERAGE DIFFERENCE BETWEEN THE VALUES, WITH ALL NINETY THREE POINTS INCLUDED, IS LOCATED ON THE CHART ENTITLED, " TESTING SIGNIFICANT DIFFERENCES BETWEEN PAIRED MEASUREMENTS", WHICH IS ALSO IN THIS SECTION. THIS IS THE FIRST CHART ON THAT PAGE. THE BROOKS VALUES FOR APO A-1, APO B, AND THE A-1/B RATIO WERE COMPARED TO THE RESPECTIVE LACKLAND AFB RESULTS TO PRODUCE A MEAN DIFFERENCE FOR THE APO A-1, APO B, AND THE A-1/B RATIO VALUES. THE MEAN DIFFERENCE FOR APO A-1 VALUES IS 16.8. THE MEAN DIFFERENCE FOR THE APO B VALUES IS 7.9 AND .05 FOR THE A-1/B RATIO

VALUES. THE MEAN IS THE AVERAGE AMOUNT OF DIFFERENCE AMONG THE POINTS. SINCE ALL THE MEANS ARE POSITIVE, WE KNOW THAT THE MAJORITY OF THE BROOKS VALUES ARE LOWER THAN THE LACKLAND VALUES. THIS CAN ALSO BE SEEN BY LOOKING AT THE CHART THAT COMPARES THE VALUES. HOWEVER, NOT ALL OF THE VALUES ARE LOWER. THERE ARE A FEW BROOKS VALUES THAT ARE HIGHER THAN THEIR RESPECTIVE LACKLAND VALUES. THESE POINTS ARE INCONSISTENT WITH THE REST OF THE POINTS, AND PERHAPS COULD BE CONSIDERED INVALID. THE REASON WHY A FEW OF THE BROOKS RESULTS ARE HIGHER IS UNKNOWN. THEREFORE, THESE RESULTS COULD BE CONSIDERED ERRONEOUS. HOWEVER, BY REMOVING THESE RESULTS, WE DO NOT IMPROVE OUR MEAN DIFFERENCES. WITH THE REMOVAL OF ALL THE HIGH VALUES, WE ACTUALLY INCREASE OUR MEAN DIFFERENCES. THE APO A-1 MEAN GOES UP TO 19.0, THE APO B GOES UP TO 12.5 AND THE A-1/B RATIO INCREASES TO .16. THE SECOND COMPARISON CHART HIGHLIGHTS THOSE BROOKS VALUES WHICH ARE HIGHER THAN THE LACKLAND VALUES. THESE VALUES ARE THE ONES THAT WERE OMITTED FOR THE NEW CALCULATED MEAN DIFFERENCES THAT FOLLOW THE ORIGINAL MEAN DIFFERENCES ON THE "TESTING SIGNIFICANT DIFFERENCES BETWEEN PAIRED MEASUREMENTS" CHART.

OBS	CASENR	A1_WH	B_WH	RAT_WH	A1_BRK	B_BRK	RAT_BRK
1	C24236	130	104	1.3	119	95	1.3
2	M24234	159	83	1.9	132	66	2.0
3	C24231	130	59	2.2	105	52	2.0
4	M24233	136	53	2.6	110	43	2.6
5	C24241	122	73	1.7	98	67	1.5
6	M24238	225	84	2.7	209	65	3.2
7	D24243	149	66	2.3	114	57	2.0
8	D24242	138	71	1.9	114	62	1.8
9	C24244	141	118	1.2	131	103	1.3
10	C24240	155	105	1.5	145	106	1.4
11	D24248	128	86	1.5	105	87	1.2
12	D24249	199	73	2.7	195	62	3.1
13	C24251	141	101	1.4	120	87	1.4
14	C24250	130	92	1.4	108	82	1.3
15	C24247	133	107	1.2	105	94	1.1
16	D24253	135	107	1.3	146	180	0.8
17	D24252	107	106	1.0	89	83	1.1
18	D24255	170	102	1.7	171	81	2.1
19	C24254	166	152	1.1	139	115	1.2
20	C24257	136	70	1.9	116	59	2.0
21	C24258	131	130	1.0	104	104	1.0
22	C24259	164	90	1.8	152	80	1.9
23	D24260	153	70	2.2	140	62	2.3
24	C24256	118	129	0.9	102	107	0.9
25	M24262	135	82	1.6	130	108	1.2
26	M24264	116	117	1.0	104	103	1.0
27	M24265	131	109	1.2	106	86	1.2
28	C24263	126	69	1.8	107	62	1.7
29	D24246	106	72	1.5	82	58	1.4
30	C24266	131	120	1.1	117	133	0.9
31	D24267	151	84	1.8	124	71	1.7
32	C24268	126	159	0.8	101	133	0.8
33	D24269	148	103	1.4	157	82	1.9
34	D24270	139	90	1.5	123	81	1.5
35	M24207	125	96	1.3	99	95	1.0
36	D24211	157	70	2.2	132	61	2.2
37	D24210	137	110	1.2	134	81	1.7
38	C24215	136	102	1.3	99	88	1.2
39	D24217	145	92	1.6	124	72	1.7
40	D24216	133	95	1.4	115	88	1.3
41	D24221	137	71	1.9	106	65	1.6
42	C24220	129	110	1.2	107	107	1.0
43	D24183	192	60	3.2	165	55	3.0
44	M24218	142	88	1.6	117	65	1.8
45	C24219	140	40	3.5	114	53	2.2
46	C24222	125	112	1.1	99	131	0.8
47	D24223	174	61	2.9	153	50	3.1
48	C24224	125	98	1.3	98	85	1.2
49	C24225	145	59	2.5	138	57	2.4
50	D24226	154	63	2.4	130	57	2.3
51	D24227	151	97	1.6	133	88	1.5
52	C24228	152	90	1.8	131	73	1.8
53	C24229	125	78	1.6	115	128	0.9
54	C24271	139	77	1.8	125	80	1.6
55	C24274	138	80	1.7	120	69	1.7
56	D24273	129	96	1.3	110	94	1.2

OBS	CASENR	A1_WH	B_WH	RAT_WH	A1_BRK	B_BRK	RAT_BRK
57	D24278	139	81	1.7	118	72	1.6
58	D24276	106	84	1.3	83	91	0.9
59	C24281	123	83	1.5	104	84	1.2
60	C24279	122	98	1.2	124	87	1.4
61	C24277	96	97	1.0	82	94	0.9
62	D24261	131	85	1.5	108	74	1.5
63	D24275	167	64	2.6	183	55	3.3
64	D24283	140	108	1.3	130	111	1.2
65	M24285	150	70	2.1	135	73	1.8
66	D24286	163	88	1.9	151	84	1.8
67	C24287	99	103	1.0	79	95	0.8
68	D24291	97	89	1.1	87	94	0.9
69	D24293	171	102	1.7	172	92	1.9
70	M24289	111	110	1.0	91	86	1.1
71	D24295	90	71	1.3	74	68	1.1
72	D24297	97	125	0.8	86	110	0.8
73	D24298	132	71	1.9	113	62	1.8
74	D24300	130	74	1.8	107	72	1.5
75	C24302	131	78	1.7	107	69	1.6
76	D24294	146	132	1.1	128	98	1.3
77	D24296	102	159	0.6	91	123	0.7
78	D24299	143	56	2.6	127	51	2.5
79	C24301	119	122	1.0	104	117	0.9
80	C24303	99	90	1.1	81	74	1.1
81	D24304	112	92	1.2	98	81	1.2
82	D24305	108	127	0.9	102	103	1.0
83	C24306	108	84	1.3	90	73	1.2
84	D24307	164	100	1.6	142	86	1.7
85	D24308	141	69	2.0	127	63	2.0
86	M24314	118	70	1.7	98	76	1.3
87	D24315	99	89	1.1	83	80	1.0
88	D24311	147	77	1.9	131	72	1.8
89	D24317	143	83	1.7	170	75	2.3
90	D24316	132	65	2.0	111	69	1.6
91	M24318	126	89	1.4	96	89	1.1
92	D24320	139	104	1.3	130	100	1.3
93	C24321	125	102	1.2	109	78	1.4

OBS	CASENR	A1_WH	B_WH	RAT_WH	A1_BRK	B_BRK	RAT_BRK
1	C24236	130	104	1.3	119	95	1.3
2	M24234	159	83	1.9	132	66	2.0
3	C24231	130	59	2.2	105	52	2.0
4	M24233	136	53	2.6	110	43	2.6
5	C24241	122	73	1.7	98	67	1.5
6	M24238	225	84	2.7	209	65	3.2
7	D24243	149	66	2.3	114	57	2.0
8	D24242	138	71	1.9	114	62	1.8
9	C24244	141	118	1.2	131	103	1.3
10	C24240	155	105	1.5	145	106	1.4
11	D24248	128	86	1.5	105	87	1.2
12	D24249	199	73	2.7	195	62	3.1
13	C24251	141	101	1.4	120	87	1.4
14	C24250	130	92	1.4	108	82	1.3
15	C24247	133	107	1.2	105	94	1.1
16	D24253	135	107	1.3	146	180	0.8
17	D24252	107	106	1.0	89	83	1.1
18	D24255	170	102	1.7	171	81	2.1
19	C24254	166	152	1.1	139	115	1.2
20	C24257	136	70	1.9	116	59	2.0
21	C24258	131	130	1.0	104	104	1.0
22	C24259	164	90	1.8	152	80	1.9
23	D24260	153	70	2.2	140	62	2.3
24	C24256	118	129	0.9	102	107	0.9
25	M24262	135	82	1.6	130	108	1.2
26	M24264	116	117	1.0	104	103	1.0
27	M24265	131	109	1.2	106	86	1.2
28	C24263	126	69	1.8	107	62	1.7
29	D24246	106	72	1.5	82	58	1.4
30	C24266	131	120	1.1	117	133	0.9
31	D24267	151	84	1.8	124	71	1.7
32	C24268	126	159	0.8	101	133	0.8
33	D24269	148	103	1.4	157	82	1.9
34	D24270	139	90	1.5	123	81	1.5
35	M24207	125	96	1.3	99	95	1.0
36	D24211	157	70	2.2	132	61	2.2
37	D24210	137	110	1.2	134	81	1.7
38	C24215	136	102	1.3	99	88	1.2
39	D24217	145	92	1.6	124	72	1.7
40	D24216	133	95	1.4	115	88	1.3
41	D24221	137	71	1.9	106	65	1.6
42	C24220	129	110	1.2	107	107	1.0
43	D24183	192	60	3.2	165	55	3.0
44	M24218	142	88	1.6	117	65	1.8
45	C24219	140	40	3.5	114	53	2.2
46	C24222	125	112	1.1	99	131	0.8
47	D24223	174	61	2.9	153	50	3.1
48	C24224	125	98	1.3	98	85	1.2
49	C24225	145	59	2.5	138	57	2.4
50	D24226	154	63	2.4	130	57	2.3
51	D24227	151	97	1.6	133	88	1.5
52	C24228	152	90	1.8	131	73	1.8
53	C24229	125	78	1.6	115	128	0.9
54	C24271	139	77	1.8	125	80	1.6
55	C24274	138	80	1.7	120	69	1.7
56	D24273	129	96	1.3	110	94	1.2

OBS	CASENR	A1_WH	B_WH	RAT_WH	A1_BRK	B_BRK	RAT_BRK
57	D24278	139	81	1.7	118	72	1.6
58	D24276	106	84	1.3	83	91	0.9
59	C24281	123	83	1.5	104	84	1.2
60	C24279	122	98	1.2	124	87	1.4
61	C24277	96	97	1.0	82	94	0.9
62	D24261	131	85	1.5	108	74	1.5
63	D24275	167	64	2.6	183	55	3.3
64	D24283	140	108	1.3	130	111	1.2
65	M24285	150	70	2.1	135	73	1.8
66	D24286	163	88	1.9	151	84	1.8
67	C24287	99	103	1.0	79	95	0.8
68	D24291	97	89	1.1	87	94	0.9
69	D24293	171	102	1.7	172	92	1.9
70	M24289	111	110	1.0	91	86	1.1
71	D24295	90	71	1.3	74	68	1.1
72	D24297	97	125	0.8	86	110	0.8
73	D24298	132	71	1.9	113	62	1.8
74	D24300	130	74	1.8	107	72	1.5
75	C24302	131	78	1.7	107	69	1.6
76	D24294	146	132	1.1	128	98	1.3
77	D24296	102	159	0.6	91	123	0.7
78	D24299	143	56	2.6	127	51	2.5
79	C24301	119	122	1.0	104	117	0.9
80	C24303	99	90	1.1	81	74	1.1
81	D24304	112	92	1.2	98	81	1.2
82	D24305	108	127	0.9	102	103	1.0
83	C24306	108	84	1.3	90	73	1.2
84	D24307	164	100	1.6	142	86	1.7
85	D24308	141	69	2.0	127	63	2.0
86	M24314	118	70	1.7	98	76	1.3
87	D24315	99	89	1.1	83	80	1.0
88	D24311	147	77	1.9	131	72	1.8
89	D24317	143	83	1.7	170	75	2.3
90	D24316	132	65	2.0	111	69	1.6
91	M24318	126	89	1.4	96	89	1.1
92	D24320	139	104	1.3	130	100	1.3
93	C24321	125	102	1.2	109	78	1.4

TESTING SIGNIFICANT DIFFERENCES BETWEEN PAIRED MEASUREMENTS 13:37 Tuesday, July 24, 1990 1

Variable	N	Mean	Std Error	T	Prob>|T|
DIFFA1	93	16.8279570	1.0736793	15.6731691	0.0001
DIFFB	93	7.8817204	1.5563177	5.0643391	0.0001
DIFFRAT	93	0.0548387	0.0275421	1.9910835	0.0494

TESTING SIGNIFICANT DIFFERENCES BETWEEN PAIRED MEASUREMENTS 13:59 Tuesday, July 24, 1990 1

Analysis Variable : DIFFA1

N	Mean	Std Error	T	Prob>|T|
86	18.9767442	0.7430438	25.5392015	0.0001

13:55 Tuesday, July 24, 1990 2

Analysis Variable : DIFFB

N	Mean	Std Error	T	Prob>|T|
77	12.4805195	0.9378519	13.3075597	0.0001

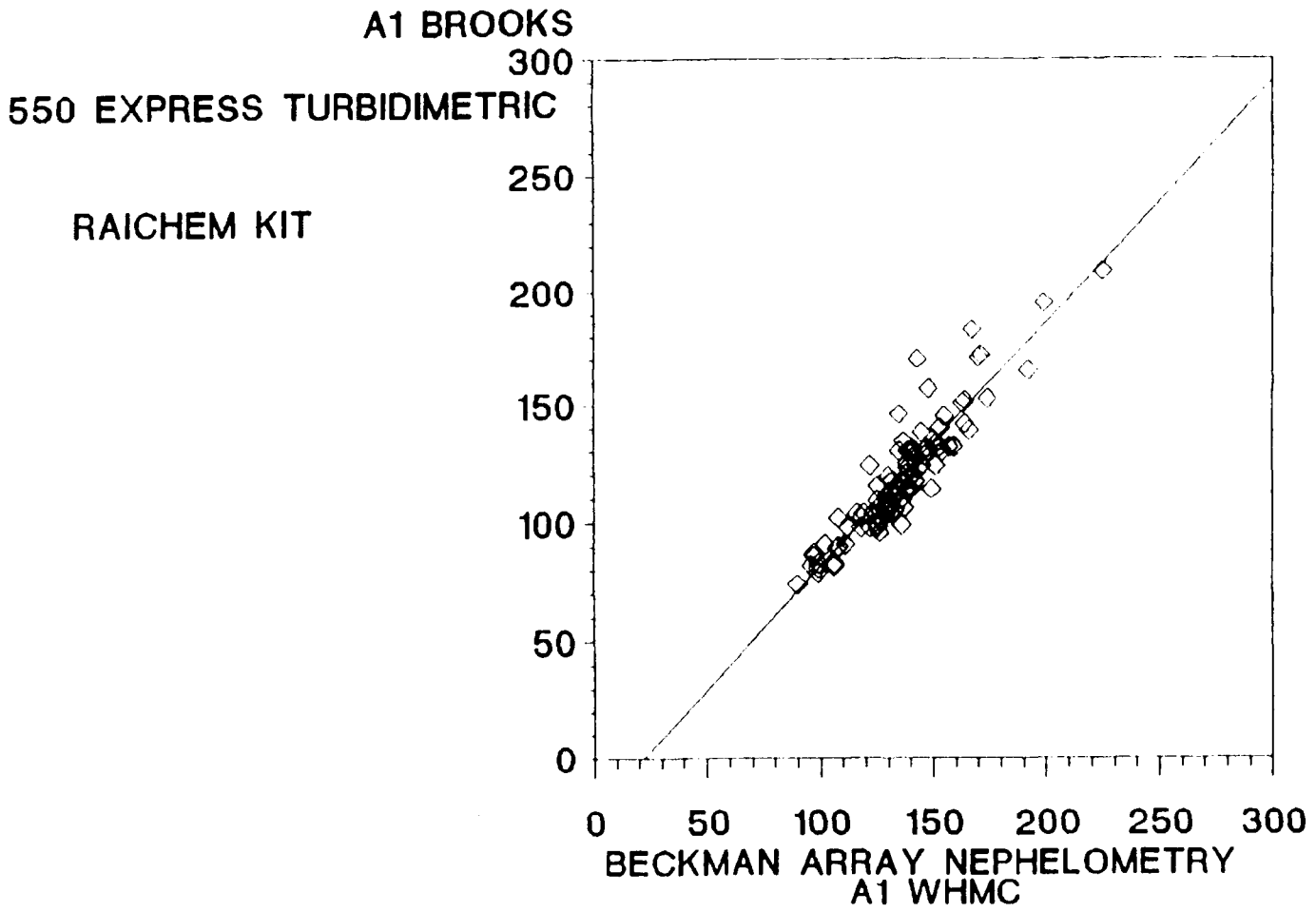
13:55 Tuesday, July 24, 1990 3

Analysis Variable : DIFFRAT

N	Mean	Std Error	T	Prob>|T|
68	0.1632353	0.0242449	6.7327654	0.0001

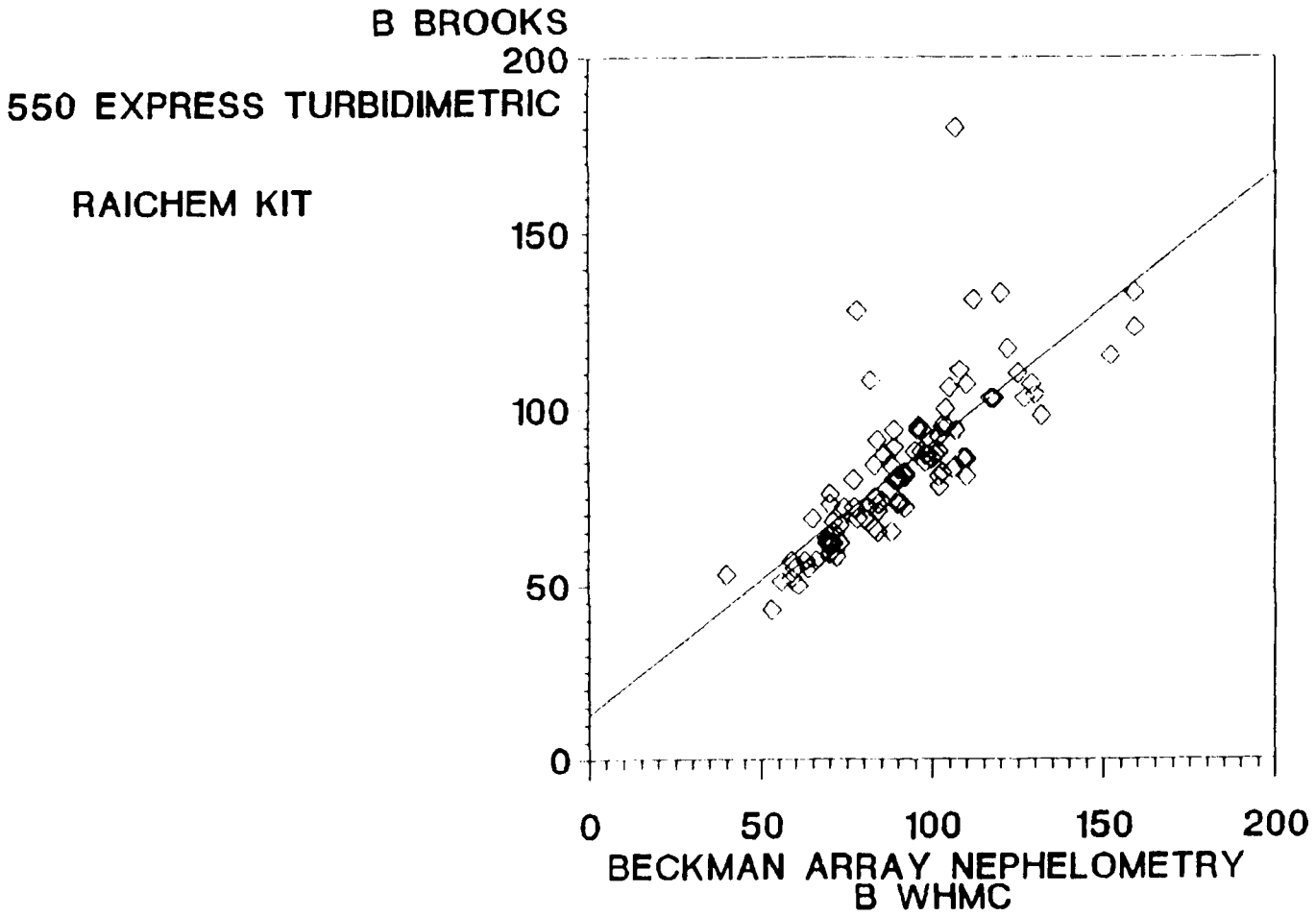
ALL SUBJECTS

Y = 1.04 * X + -22.9
Root MSE = 10.360
r = 0.917 rsquare = 0.842
n = 93



ALL SUBJECTS

Y = 0.77 * X + 12.63
Root MSE = 14.188
r = 0.780 rsquare = 0.609
n = 93



ALL SUBJECTS

Y = 0.95 * X + 0.02

Root MSE = 0.266

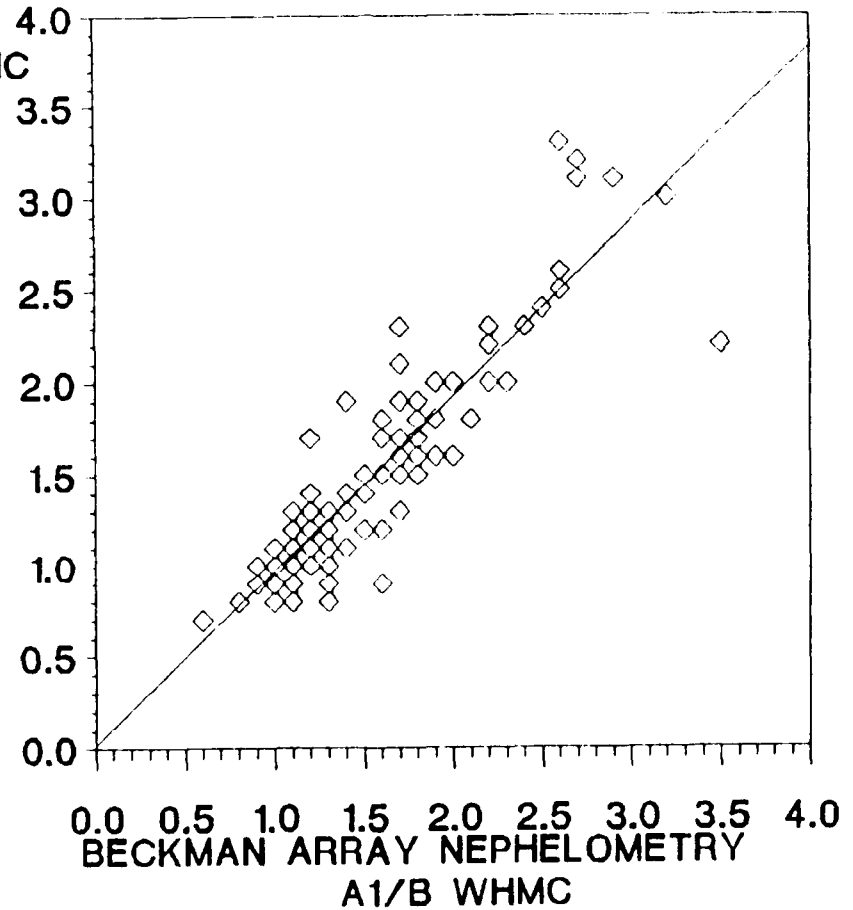
r = 0.893 rsquare = 0.797

n = 93

A1/B BROOKS

550 EXPRESS TURBIDIMETRIC

RAICHEM KIT



APOLIPOPROTEIN COMPARISON STUDY GRAPH ANALYSIS

THE LINEAR REGRESSION GRAPHS THAT FOLLOW SHOW COMPARISONS BETWEEN THE BROOKS AND LACKLAND VALUES FOR APO A-1, APO B, AND THE A-1/B RATIO. LOOKING AT THE APO A-1 COMPARISON GRAPH, WE SEE A GOOD CORRELATION UP TO ABOUT THE POINT (150,150). AFTER THIS, THE POINTS BEGIN TO SCATTER OUT. ALTHOUGH THE CORRELATION LOOKS GREAT, ONE MUST REALIZE THAT THE LINE RUNNING THROUGH THESE POINTS IS NOT AT A 45 DEGREE ANGLE, WHICH IS WHERE IT IS SUPPOSED TO BE IF THE VALUES FROM BROOKS AND LACKLAND WERE EXACTLY THE SAME. THE SLOPE IS 1.04, WHICH IS CLOSE TO 1.00, THE SLOPE OF PERFECT CORRELATION. HOWEVER, THE Y-INTERCEPT IS NEGATIVE INSTEAD OF BEING ZERO. THE Y-INTERCEPT IS NEGATIVE BECAUSE THE MAJORITY OF THE BROOKS VALUES ARE LOWER THAN THEIR RESPECTIVE LACKLAND VALUES AND THERE IS ALSO A SCATTERING OF HIGHER BROOKS VALUES NEAR THE HIGH END OF THE GRAPH. THE APO B VALUES CORRELATE EVEN LESS THAN THE APO A-1'S DO. THE SCATTER ABOUT THE LINE IS GREATER ON THE APO B GRAPH AND THERE ARE MORE PREDOMINANT OUTLIERS. THE LOW SLOPE OF .77 AND THE HIGH Y-INTERCEPT OF 12.6 ARE ALSO TESTAMENT TO THE GRAPH'S LACK OF TIGHT CORRELATION NECESSARY FOR A SUCCESSFUL CONVERSION TO OUR CIBA-CORNING 550 EXPRESS FROM THE BECKMAN ARRAY.

ALTHOUGH NEITHER OF THE FIRST TWO GRAPHS PROVIDE POSITIVE EVIDENCE THAT THERE IS A GOOD CORRELATION OF

VALUES, THE A-1/B RATIO GRAPH LOOKS MUCH MORE PROMISING. THE SLOPE OF .95 AND THE Y-INTERCEPT OF .02. INDICATE A RELATIONSHIP WITH EXCELLENT CORRELATION. HOWEVER, ONE REALIZES THESE NUMBERS ARE DECEIVING WHEN VIEWING THE SCATTER OF POINTS ON THE GRAPH. THE DECEPTION LIES IN THE FACT THAT A SMALL GROUP OF POINTS WITH RADICALLY HIGHER BROOKS RATIOS OFFSET THE REMAINING BROOKS VALUES THAT ARE ALL SLIGHTLY LOWER THAN THEIR RESPECTIVE LACKLAND VALUES. BASICALLY, A SMALL NUMBER OF VALUES WITH A BIG NEGATIVE DIFFERENCE OFFSETS A LARGE NUMBER OF VALUES WITH A SMALL POSITIVE DIFFERENCE.

HAD ALL THE BROOKS VALUES BEEN LESS THAN THE WILFORD HALL VALUES FOR APO A-1, APO B, AND THE A-1/B RATIO, THEN PERHAPS A PERCENTAGE DIFFERENCE COULD HAVE BEEN CALCULATED TO ALLEVIATE THE DEFICIENCY. HOWEVER, WITH NO CONSISTENT PERCENTAGE DIFFERENCE, (ie. ALL BROOKS VALUES ARE 10 TO 15% LOWER THAN THEIR RESPECTIVE LACKLAND VALUES), AND SOME BROOKS VALUES BEING HIGHER THAN THE LACKLAND VALUES, NO TRUE PATTERN CAN BE DEVELOPED. EVEN WITH THE HIGHER BROOKS VALUES REMOVED, THE SPREAD IN MEAN DIFFERENCE IS TOO GREAT TO SET A STANDARD PERCENT DIFFERENCE. BECAUSE WE HAVE NOT BEEN ABLE TO DETERMINE WHY THESE POINTS ARE HIGHER, THERE IS NO REASON WHY THEY CAN BE LEGITIMATELY IGNORED. FOR THESE REASONS, THESE RESULTS REMAIN INCONCLUSIVE AND A CONVERSION FROM THE WILFORD HALL MEDICAL CENTER'S BECKMAN ARRAY TO OUR CIBA-CORNING 550 EXPRESS SHOULD NOT OCCUR UNTIL ADDITIONAL

RESEARCH HAS BEEN DONE TO PROVE THAT THE RESULTS RECEIVED FROM OUR 550 EXPRESS CAN BE DEEMED MORE ACCURATE AND CONSISTENT OR UNTIL A STANDARD PERCENT DIFFERENCE CAN BE DETECTED AND IMPLEMENTED IN COMPARING APOLIPOPROTEIN VALUES.

CAD PREDICTION STUDY CHART DESCRIPTION AND EXPLANATION

THIS CHART IS A COMPILATION OF ALL THE DATA USED IN MY RESEARCH FOR EVERY PATIENT IN THE CAD PREDICTION STUDY. THE FIRST COLUMN, ENTITLED "OBS", IS THE LINE NUMBERS FOR EACH ROW. ALONG WITH THE CASE NUMBERS, WHICH ARE IN COLUMN TWO, THIS IS ANOTHER WAY TO IDENTIFY A PARTICULAR SUBJECT. THE THIRD COLUMN IS THE APOLIPOPROTEIN A-1 VALUES FROM WHMC, LAFB. THESE APO A-1 VALUES AND THE APO B VALUES FOUND IN COLUMN FOUR ARE THE RESULTS FROM THE BECKMAN ARRAY AT WHMC. (SEE NOTE ON CHART OF GRAPHS USED) THE NEXT COLUMN IS THE A-1/B RATIO.(A1_B_RAT) THIS RATIO IS DERIVED BY DIVIDING THE APO B VALUES INTO THE APO A-1 VALUES. THE NEXT TWO COLUMNS CONTAIN VALUES THAT WERE DETERMINED BY THE ABBOTT VP, AS DESCRIBED IN THE "PROCEDURE" SECTION OF THIS REPORT. TOTAL CHOLESTEROL IS THE NEXT COLUMN, AND IS ABBREVIATED "TC", "CHOL" OR "TCHOL". THE SEVENTH COLUMN IS HDL CHOLESTEROL, WHICH IS ABBREVIATED "HDL" OR "HDL CHOL".

THE FOLLOWING COLUMN IS THE RATIO OF TOTAL CHOLESTEROL TO HDL CHOLESTEROL, WHICH IS ABBREVIATED AS "C H RAT" OR "TC HDL CHOL RAT". THE TRIGLYCERIDES ARE NEXT, AND ARE SIMPLY REFERRED TO AS "TRIG". FOLLOWING THE "TRIG" COLUMN IS THE COLUMN HEADED "RISK IDX", WHICH STANDS FOR RISK INDEX. THE RISK INDEX IS A FORMULA THAT WAS DERIVED TO ASSIST PHYSICIANS IN DETERMINING A PATIENT'S RISK FOR DEVELOPING CAD. THE FORMULA IS AS FOLLOWS:

$$\text{RISK INDEX} = (\text{PATIENT'S AGE})^2 \times (\text{TC/HDL CHOL RAT} - 1.0)$$

VALUES UNDER 12,000 ARE CONSIDERED NORMAL, BUT A VERY YOUNG PATIENT WITH EXTREMELY HIGH CHOLESTEROL VALUES MAY NOT SEEM AT RISK ACCORDING TO THE RISK INDEX BECAUSE OF HIS AGE. LIKEWISE, AN OLDER PATIENT WITH EXTREMELY LOW CHOLESTEROL VALUES MAY SEEM MORE AT RISK THAN HE ACTUALLY IS BECAUSE AGE PLAYS AN IMPORTANT ROLE IN THE RISK INDEX FORMULA. USUALLY, THE RISK INDEX IS A GOOD INDICATOR, EXCEPT IN EXTREME INSTANCES. THE FINAL COLUMN IS LDL CHOLESTEROL, ABBREVIATED "LDL" OR "LDL CHOL". LDL CHOLESTEROL VALUES ARE CALCULATED BY FORMULA, RATHER THAN DETERMINED EXPERIMENTALLY. THE FORMULA FOR DETERMINING LDL CHOLESTEROL IS:

$$\text{LDL CHOL} = \text{TOTAL CHOL} - \text{HDL CHOL} - (\text{TRIGLYCERIDES}/5)$$

BECAUSE THIS IS A CALCULATED VALUE RATHER THAN A EXPERIMENTALLY DETERMINED VALUE, THERE CAN BE A DISCREPANCY IN THE LDL CHOLESTEROL VALUE IF A PATIENT'S TRIGLYCERIDE VALUE IS EXTREMELY HIGH. FOR INSTANCE, IF A PATIENT HAD A TOTAL CHOLESTEROL OF 180, A HDL CHOL OF 60, AND A TRIGLYCERIDE OF 700, HIS CALCULATED LDL CHOLESTEROL WOULD BE -20. THIS, OF COURSE, IS OBVIOUSLY INCORRECT. THIS IS WHY A CALCULATED LDL CHOLESTEROL VALUE MUST BE VIEWED IN ACCORDANCE WITH TOTAL CHOLESTEROL, HDL CHOLESTEROL AND TRIGLYCERIDE VALUES TO DETERMINE THE EXTENT OF ITS VALIDITY.

OBS	CASENR	A1	B	A1_B_RAT	CHOL	HDL	C_H_RAT	TRIG	RISK_IDX	LDL
1	C24236	130	104	1.3	187	30	6.2	176	14700	122
2	M24234	159	83	1.9	197	52	3.8	68	9060	131
3	C24231	130	59	2.2	141	43	3.3	67	2482	85
4	M24233	136	53	2.6	120	39	3.1	66	6748	68
5	C24241	122	73	1.7	162	35	4.6	115	2090	104
6	M24238	225	84	2.7	218	84	2.6	43	5003	125
7	D24243	149	66	2.3	161	48	3.4	49	3051	103
8	D24242	138	71	1.9	165	47	3.5	71	4220	104
9	C24244	141	118	1.2	240	43	5.6	113	5612	174
10	C24240	155	105	1.5	225	42	5.3	228	6971	137
11	D24248	128	86	1.5	192	34	5.6	141	7435	130
12	D24249	199	73	2.7	200	66	3.0	66	4111	121
13	C24250	130	92	1.4	191	38	5.0	114	4385	130
14	C24251	141	101	1.4	211	45	4.7	114	2494	143
15	C24247	133	107	1.2	227	39	5.8	115	13541	165
16	D24253	135	107	1.3	225	34	6.6	531	12409	85
17	D24252	107	106	1.0	210	34	6.2	72	15095	162
18	D24255	170	102	1.7	218	58	3.8	97	6094	141
19	C24254	166	152	1.1	315	57	5.5	86	9578	241
20	C24257	136	70	1.9	160	51	3.1	52	6944	99
21	C24258	131	130	1.0	235	38	6.2	112	14018	175
22	C24259	164	90	1.8	196	54	3.6	136	8846	115
23	D24260	153	70	2.2	163	51	3.2	56	1373	101
24	C24256	118	129	0.9	258	41	6.3	141	3308	189
25	M24262	135	82	1.6	165	28	5.9	351	15897	67
26	M24264	116	117	1.0	221	32	6.9	183	19189	152
27	M24265	131	109	1.2	195	32	6.1	122	15974	139
28	C24263	126	69	1.8	164	45	3.6	90	9205	101
29	D24246	106	72	1.5	156	32	4.9	55	7502	113
30	C24266	131	120	1.1	248	38	6.5	243	8402	161
31	D24267	151	84	1.8	199	54	3.7	61	4514	133
32	C24268	126	159	0.8	259	35	7.4	252	16646	174
33	D24269	148	103	1.4	225	62	3.6	88	5090	145
34	D24270	139	90	1.5	193	46	4.2	103	5909	126
35	M24207	125	96	1.3	200	34	5.9	151	15311	136
36	D24211	157	70	2.2	179	50	3.6	72	4128	115
37	D24210	137	110	1.2	239	40	6.0	68	10125	185
38	C24215	136	102	1.3	224	38	5.9	82	7832	170
39	D24217	145	92	1.6	186	39	4.8	73	6649	132
40	D24216	133	95	1.4	188	34	5.5	164	7990	121
41	D24221	137	71	1.9	182	45	4.0	66	3315	124
42	C24220	129	110	1.2	219	31	7.1	173	11279	153
43	D24183	192	60	3.2	179	67	2.7	51	3385	102
44	M24218	142	88	1.6	201	46	4.4	125	10567	130
45	C24219	140	40	3.5	121	36	3.4	127	4165	60
46	C24222	125	112	1.1	242	37	6.5	235	8001	158
47	D24223	174	61	2.9	177	70	2.5	35	3234	100
48	C24224	125	98	1.3	207	35	5.9	89	2379	154
49	C24225	145	59	2.5	149	46	3.2	80	3233	87
50	D24226	154	63	2.4	166	47	3.5	76	4902	104
51	D24227	151	97	1.6	231	46	5.0	96	11727	166
52	C24228	152	90	1.8	203	49	4.1	78	7546	138
53	C24229	125	78	1.6	183	26	7.0	310	5803	95
54	C24271	139	77	1.8	185	50	3.7	76	2117	120
55	C24274	138	80	1.7	174	47	3.7	87	1429	110
56	D24273	129	96	1.3	189	40	4.7	188	4306	111

OBS	CASENR	A1	B	A1_B_RAT	CHOL	HDL	C_H_RAT	TRIG	RISK_IDX	LDL
57	D24278	139	81	1.7	203	50	4.1	51	5144	143
58	D24276	106	84	1.3	171	29	5.9	156	7834	111
59	C24281	123	83	1.5	170	31	5.5	144	10766	110
60	C24279	122	98	1.2	194	33	5.9	180	8798	125
61	C24277	96	97	1.0	176	21	8.4	204	10658	114
62	D24261	131	85	1.5	180	47	3.8	89	4757	115
63	D24275	167	64	2.6	168	73	2.3	35	5498	88
64	D24283	140	108	1.3	211	40	5.3	236	12932	124
65	M24285	150	70	2.1	149	42	3.5	117	8277	84
66	D24286	163	88	1.9	204	57	3.6	128	5942	121
67	C24287	99	103	1.0	200	31	6.5	133	12561	142
68	D24291	97	89	1.1	170	28	6.1	183	5863	105
69	D24293	171	102	1.7	219	59	3.7	111	5492	138
70	M24289	111	110	1.0	204	36	5.7	113	16245	145
71	D24295	90	71	1.3	140	26	5.4	113	8879	91
72	D24297	97	125	0.8	228	28	8.1	185	17857	163
73	D24298	132	71	1.9	163	48	3.4	93	4430	96
74	D24300	130	74	1.8	173	51	3.4	73	4631	107
75	C24302	131	78	1.7	185	50	3.7	74	2430	120
76	D24294	146	132	1.1	240	52	4.6	63	7321	175
77	D24296	102	159	0.6	281	33	8.5	178	15902	212
78	D24299	143	56	2.6	148	57	2.6	62	2816	79
79	C24301	119	122	1.0	232	35	6.6	161	12434	165
80	C24303	99	90	1.1	173	35	4.9	68	5693	124
81	D24304	112	92	1.2	174	38	4.6	105	6617	115
82	D24305	108	127	0.9	235	33	7.1	112	14103	180
83	C24306	108	84	1.3	164	36	4.6	72	2404	114
84	D24307	164	100	1.6	238	75	3.2	37	3834	156
85	D24308	141	69	2.0	169	60	2.8	49	1978	99
86	M24314	118	70	1.7	148	36	4.1	95	10108	93
87	D24315	99	89	1.1	179	33	5.4	84	15401	129
88	D24311	147	77	1.9	179	53	3.4	84	7997	109
89	D24317	143	83	1.7	227	70	3.2	33	6065	150
90	D24316	132	65	2.0	152	42	3.6	101	2517	90
91	M24318	126	89	1.4	185	40	4.6	98	11368	125
92	D24320	139	104	1.3	223	48	4.6	77	3970	160
93	C24321	125	102	1.2	207	42	4.9	62	7955	153
94	D24322	139	62	2.2	153	62	2.5	50	845	81
95	D24323	127	92	1.4	191	39	4.9	113	6236	129
96	C24325	139	97	1.4	179	74	2.4	29	1640	99
97	D24326	169	62	2.7	184	41	4.5	138	6449	115
98	D24328	157	108	1.5	241	56	4.3	69	7298	171
99	C24330	116	79	1.5	182	42	4.3	80	1920	124
100	M24313	130	111	1.2	235	42	5.6	125	14411	168
101	C24332	141	87	1.6	190	42	4.5	152	6822	118
102	C24333	144	70	2.1	184	62	3.0	26	3471	117
103	M24334	122	158	0.8	313	40	7.8	206	21403	232
104	D24335	129	77	1.7	175	52	3.4	80	4173	107
105	C24352	112	67	1.7	157	41	3.8	59	3271	104
106	M24337	218	74	2.9	230	90	2.6	98	4878	120
107	D24339	126	67	1.9	140	39	3.6	97	4568	82
108	C24342	102	85	1.2	166	29	5.7	138	7941	109
109	C24346	129	137	0.9	278	42	6.6	180	7282	200
110	D24347	137	86	1.6	205	38	5.4	228	7388	121
111	D24350	139	78	1.8	179	46	3.9	156	5614	102
112	D24351	124	95	1.3	193	39	4.9	94	6318	135

OBS	CASENR	A1	B	A1_B_RAT	CHOL	HDL	C_H_RAT	TRIG	RISK_IDX	LDL
113	D24344	151	68	2.2	172	59	2.9	79	4788	97
114	C24353	136	61	2.2	145	52	2.8	58	1831	81
115	M24331	124	101	1.2	208	42	5.0	54	12395	155
116	M24354	130	103	1.3	219	45	4.9	122	13460	150
117	M24357	92	83	1.1	164	23	7.1	279	19225	85
118	C24356	134	63	2.1	149	46	3.2	87	3233	86
119	D24355	149	85	1.8	218	65	3.4	55	4767	142
120	D24358	119	115	1.0	233	34	6.9	104	14053	178
121	D24360	114	115	1.0	219	35	6.3	92	10646	166
122	C24362	142	110	1.3	245	55	4.5	46	7959	181
123	D24341	139	117	1.2	241	39	6.2	505	16828	101
124	C24359	126	72	1.8	160	47	3.4	64	3472	100
125	C24365	112	124	0.9	219	34	6.4	173	10534	150

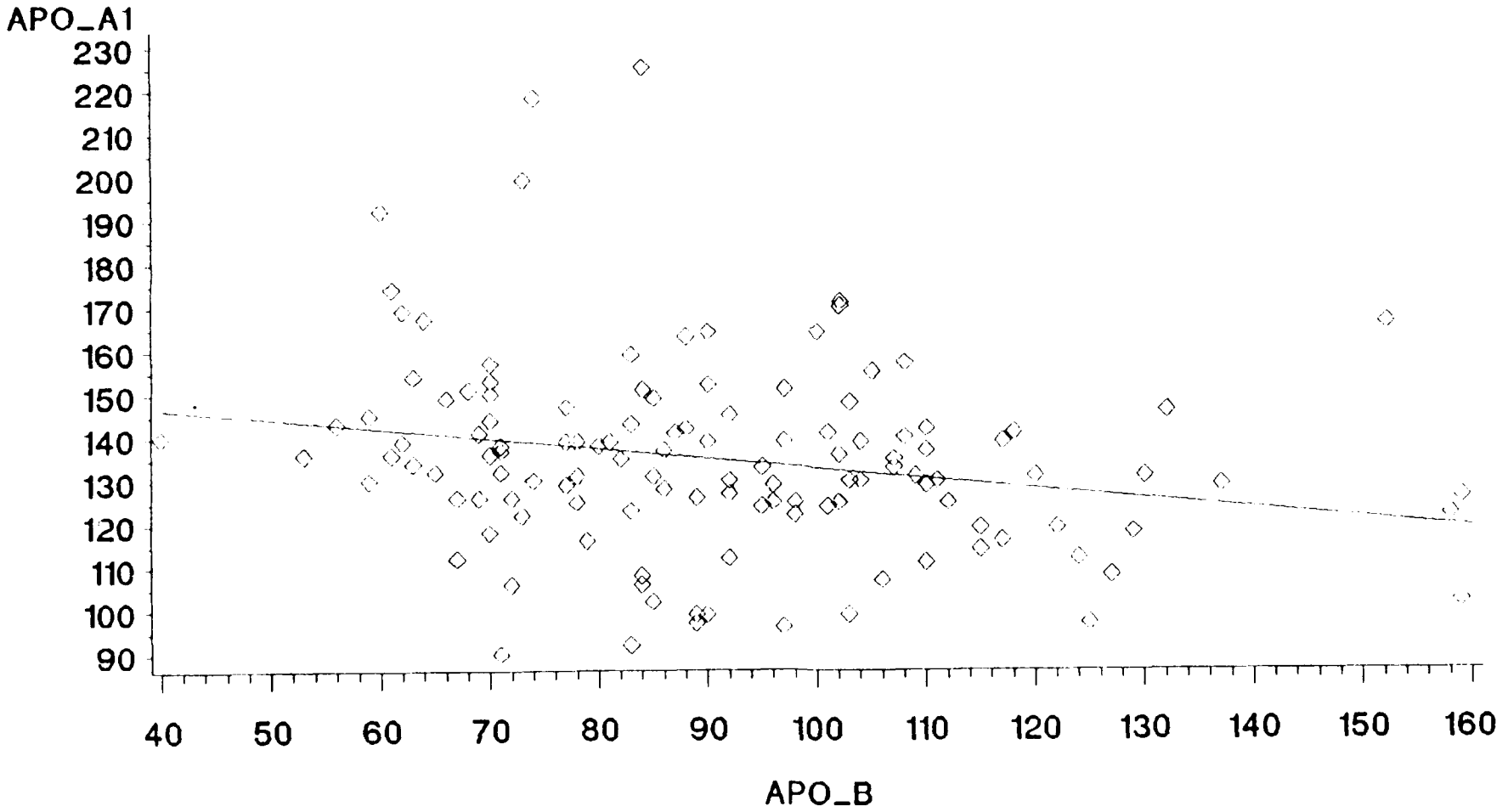
LIST OF GRAPHS USED IN CAD PREDICTION STUDY

1. APO A-1 VS. APO B
2. APO A-1 VS. LDL
3. APO A-1 VS. TRIGLYCERIDE
4. APO A-1 VS. HDL
5. APO A-1 VS. TOTAL CHOL.(TC)
6. APO A-1 VS. TC/HDL CHOL RATIO
7. APO A-1 VS. RISK INDEX
8. APO A-1 VS. A-1/B RATIO
9. APO B VS. LDL
10. APO B VS. TRIGLYCERIDE
11. APO B VS. HDL
12. APO B VS. TC
13. APO B VS. TC/HDL CHOL RATIO
14. APO B VS. RISK INDEX
15. APO B VS. A-1/B RATIO(RAT)
16. LDL VS. TRIGLYCERIDE(TRIG)
17. LDL VS. HDL
18. LDL VS. TC
19. LDL VS. TC/HDL CHOL RAT
20. LDL VS. RISK INDEX
21. LDL VS. A-1/B RAT
22. TRIG VS. HDL
23. TRIG VS. TC
24. TRIG VS. TC/HDL CHOL RAT
25. TRIG VS. RISK INDEX
26. TRIG VS. A-1/B RAT
27. HDL VS. TC
28. HDL VS. TC/HDL CHOL RAT
29. HDL VS. RISK INDEX
30. HDL VS. A-1/B RAT
31. TC VS. TC/HDL CHOL RAT
32. TC VS. RISK INDEX(IDX)
33. TC VS. A-1/B RAT
34. TC/HDL CHOL VS.RISK IDX
35. TC/HDL CHOL VS. A-1/B RAT
36. RISK IDX VS. A-1/B RAT

NOTE: ALL APO VALUES USED ON THESE GRAPHS WERE THE VALUES OBTAINED FROM THE BECKMAN ARRAY AT WHMC, LAFB. THESE VALUES WERE USED RATHER THAN THE BROOKS AFB VALUES BECAUSE THEY ARE THE STANDARD BY WHICH WE COMPARE OUR BROOKS AFB VALUES TO. ALL OTHER VALUES WERE CALCULATED OR OBTAINED FROM TESTS DONE AT THE BROOKS AFB CLINICAL PATHOLOGY LABORATORY.

ALL SUBJECTS

Y = -0.23 * X + 156.0
Root MSE = 21.919
r = -0.236 rsquare = 0.056
n = 125



ALL SUBJECTS

Y = -0.05 * X + 141.2
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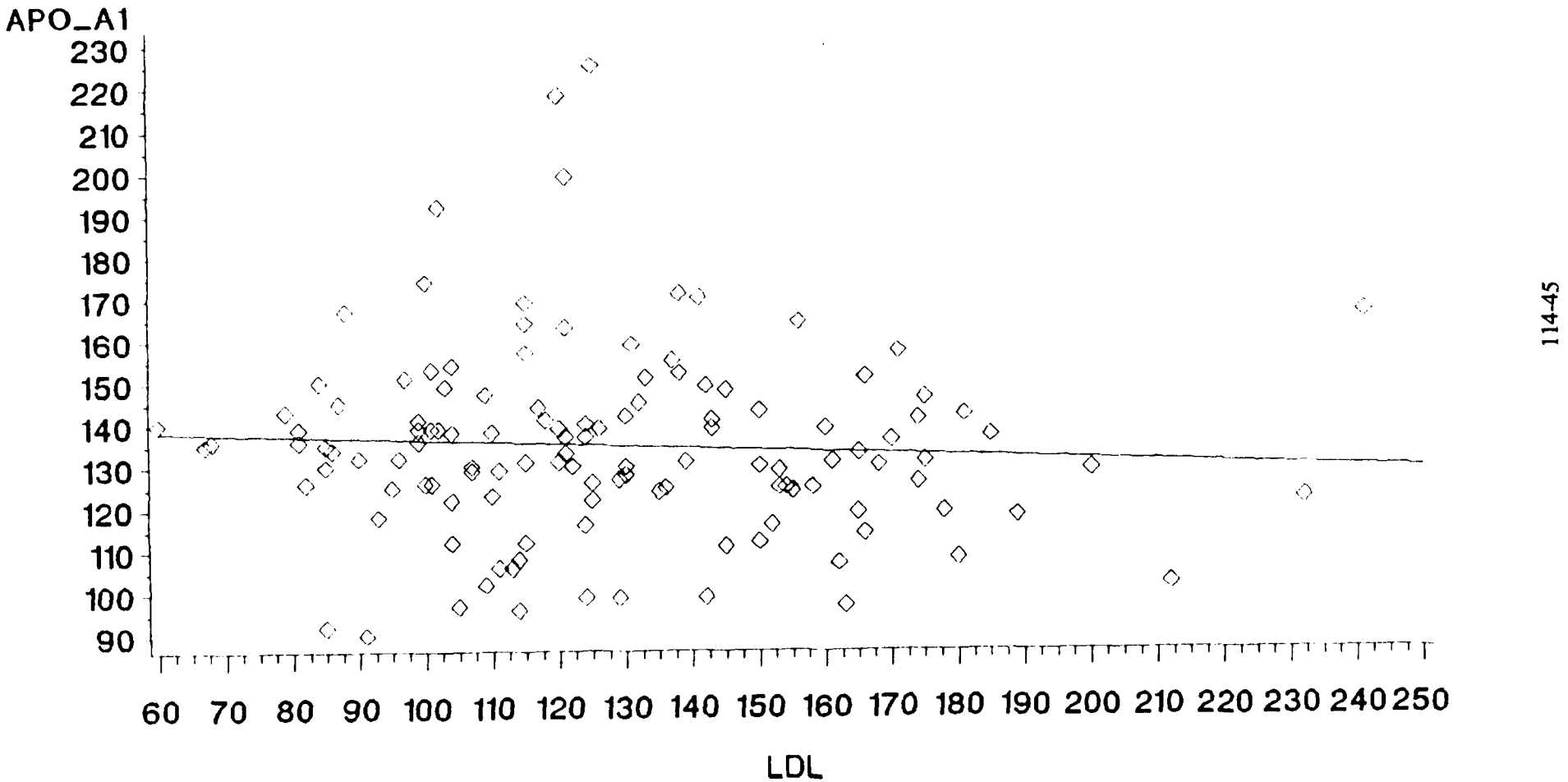
r = -0.073 rsquare = 0.005
n = 125



114-45

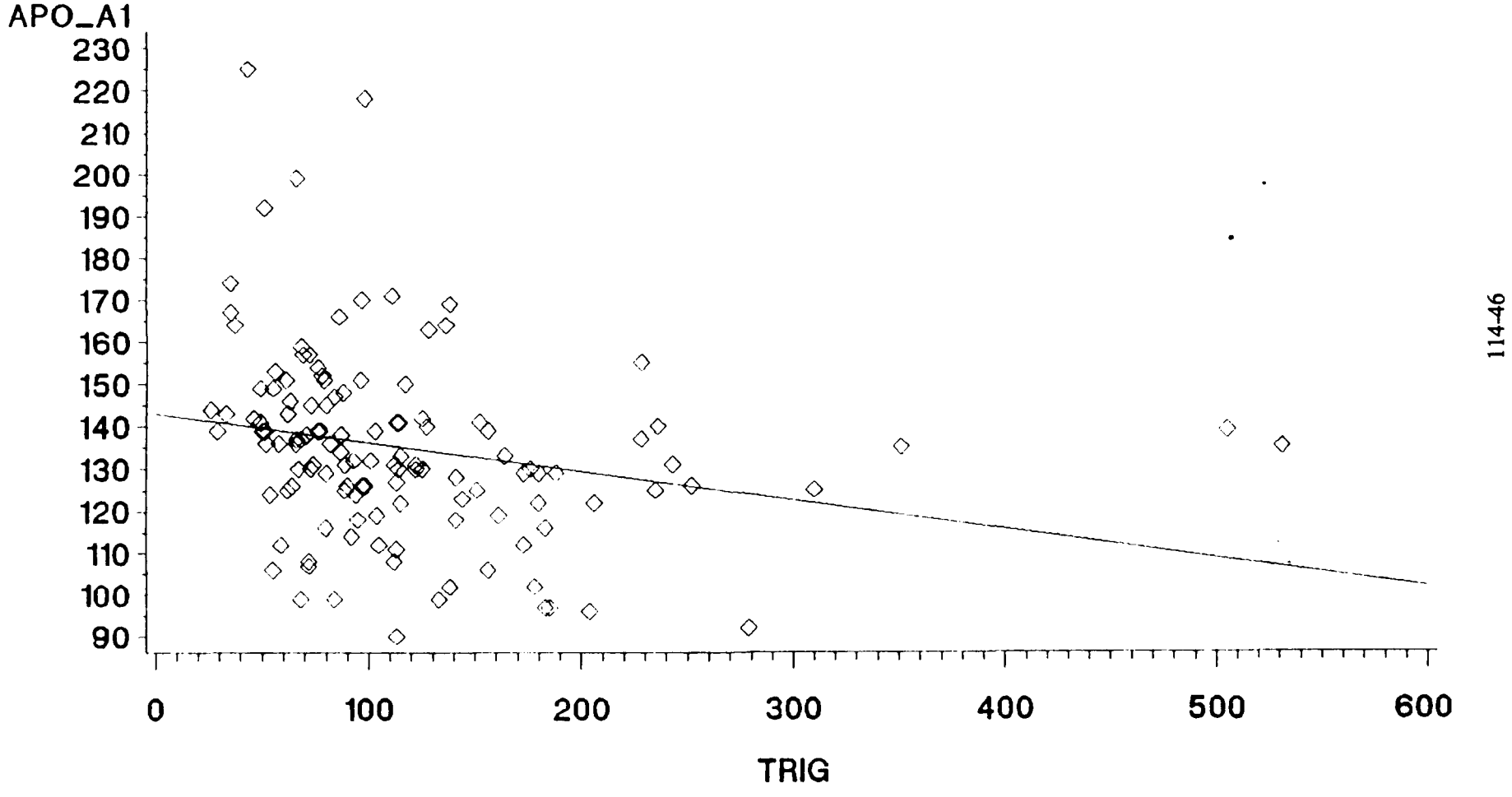
ALL SUBJECTS

Y = -0.07 * X + 142.9

Root MSE = 21.901

r = -0.239 rsquare = 0.057

n = 125



114-46

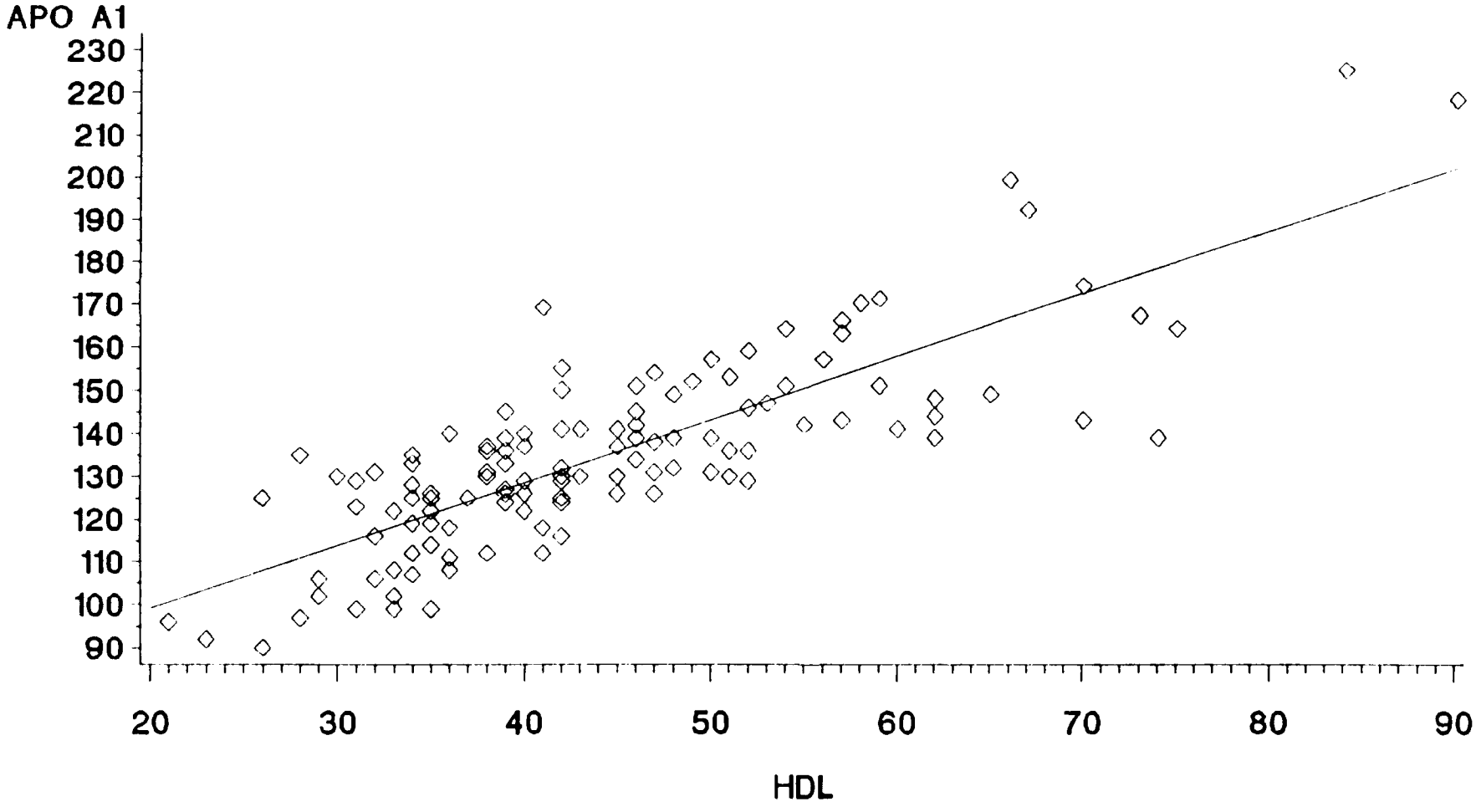
ALL SUBJECTS

Y = 1.46 * X + 69.95

Root MSE = 13.129

r = 0.813 rsquare = 0.661

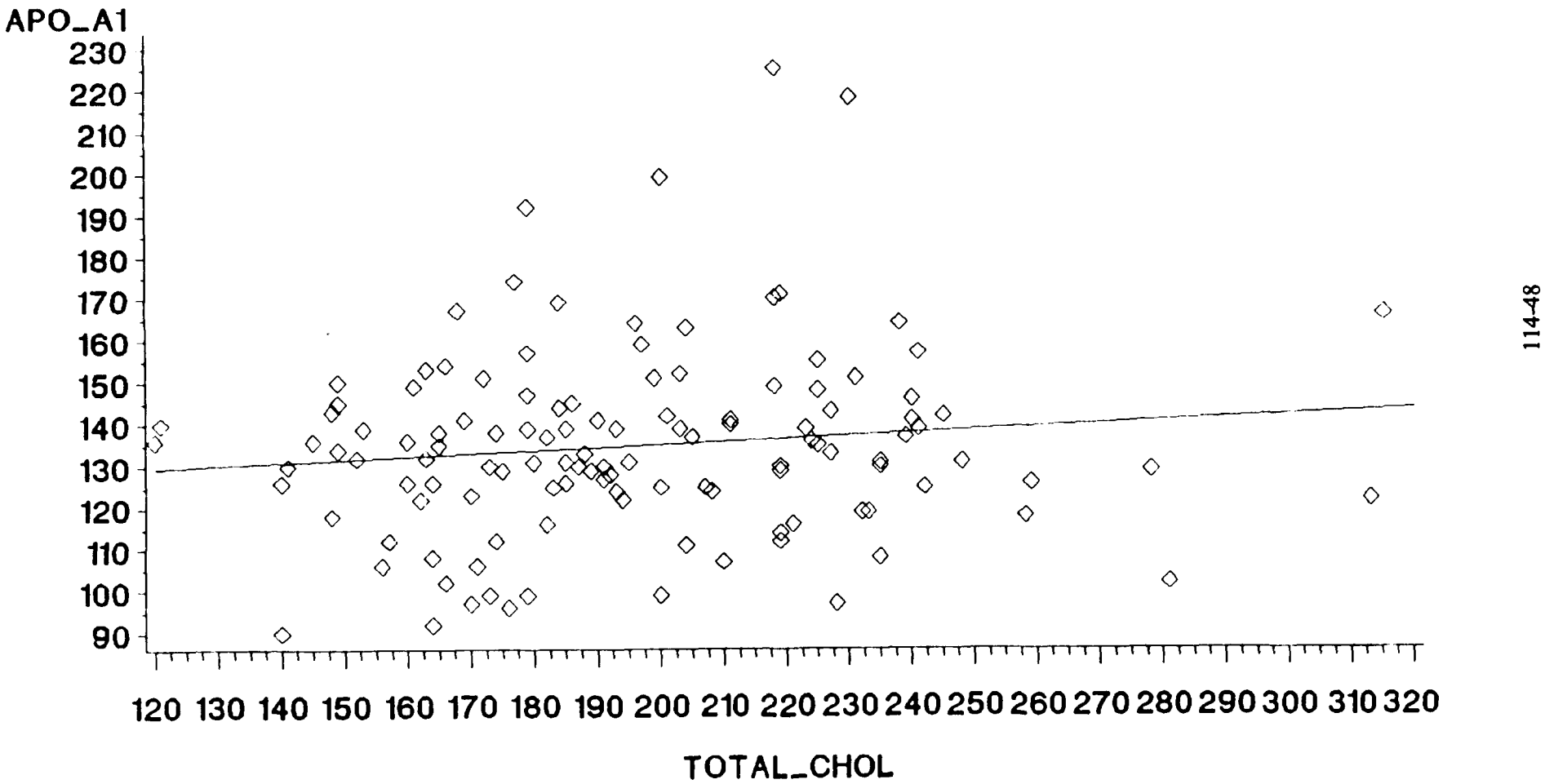
n = 125



114-47

ALL SUBJECTS

Y = 0.07 * X + 121.4
Root MSE = 22.421
r = 0.109 rsquare = 0.012
n = 125



114-48

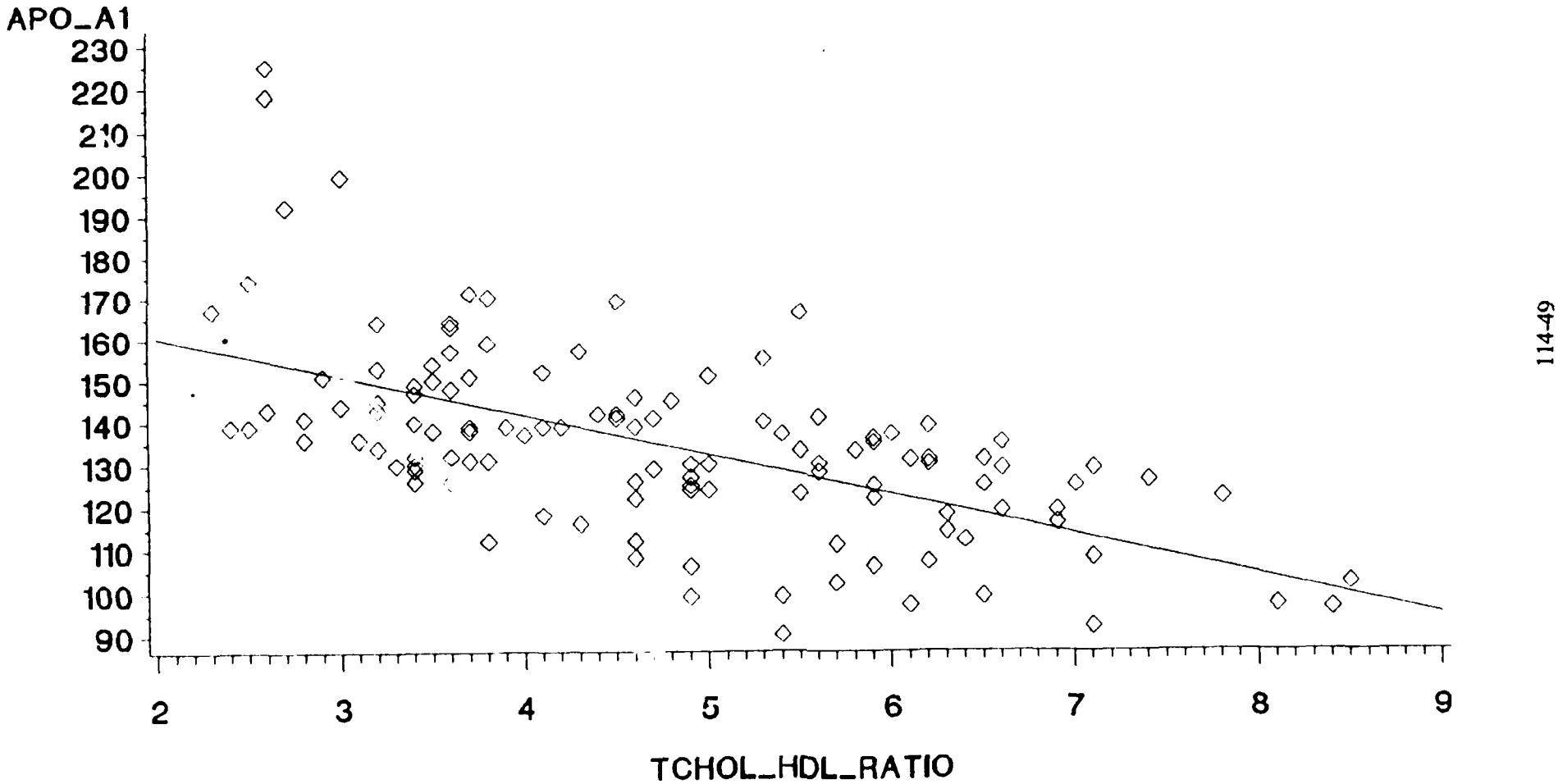
ALL SUBJECTS

Y = -9.39 * X + 179.3

Root MSE = 17.938

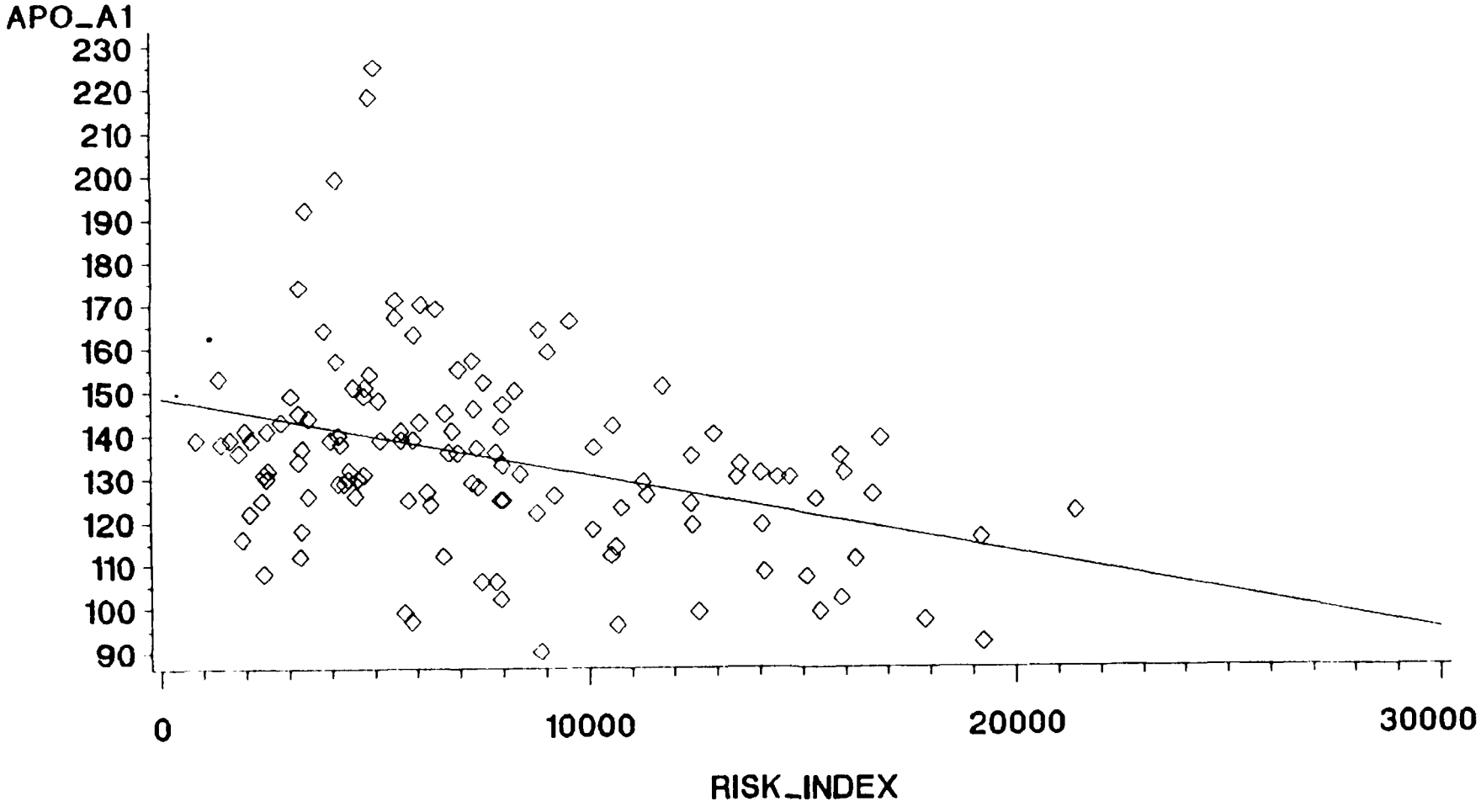
r = -0.606 rsquare = 0.368

n = 125



ALL SUBJECTS

Y = -0.00 * X + 148.8
Root MSE = 20.952
r = -0.370 rsquare = 0.137
n = 125



114-50

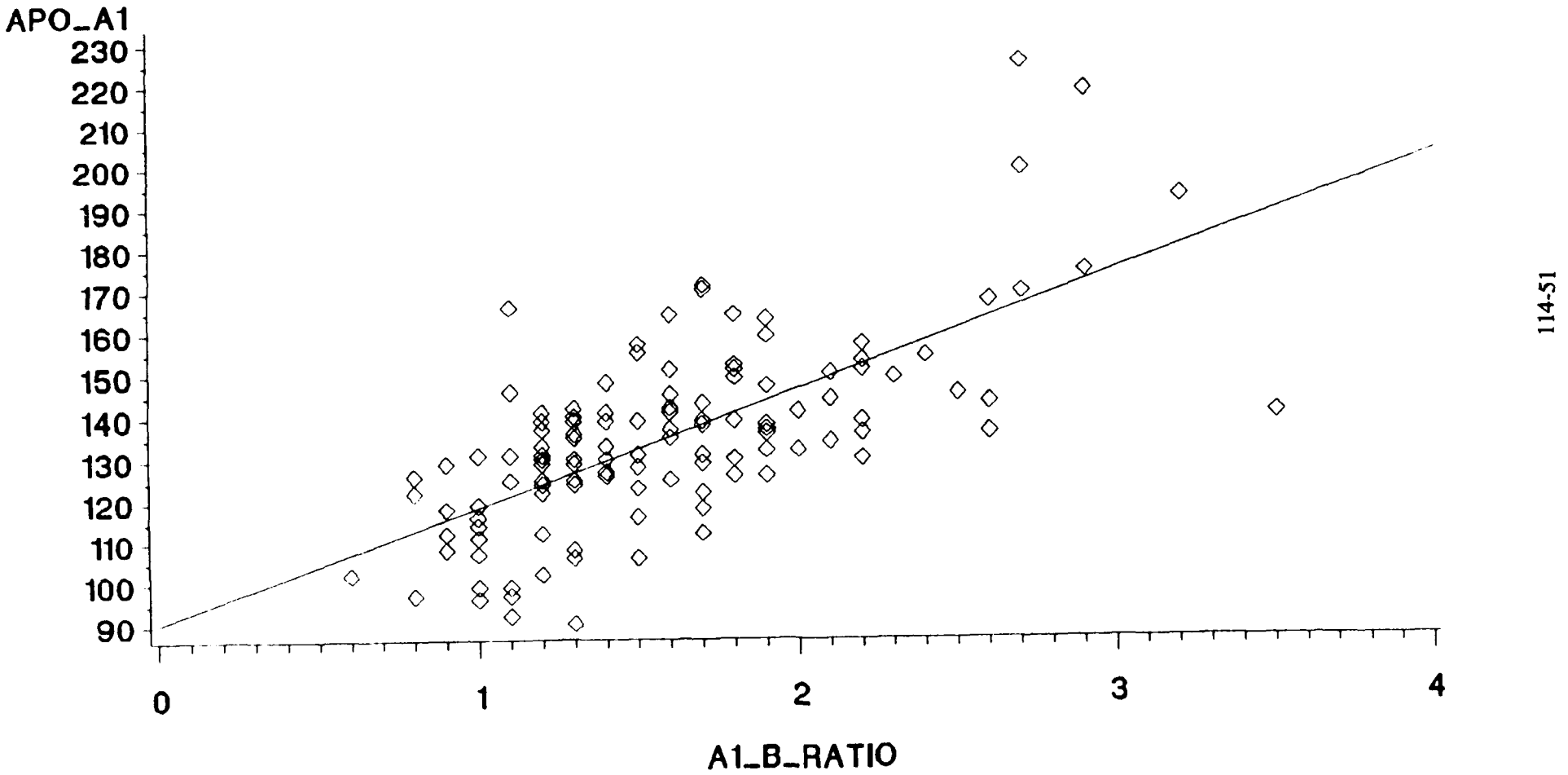
ALL SUBJECTS

Y = 28.07 * X + 90.24

Root MSE = 16.644

r = 0.675 rsquare = 0.456

n = 125



114-51

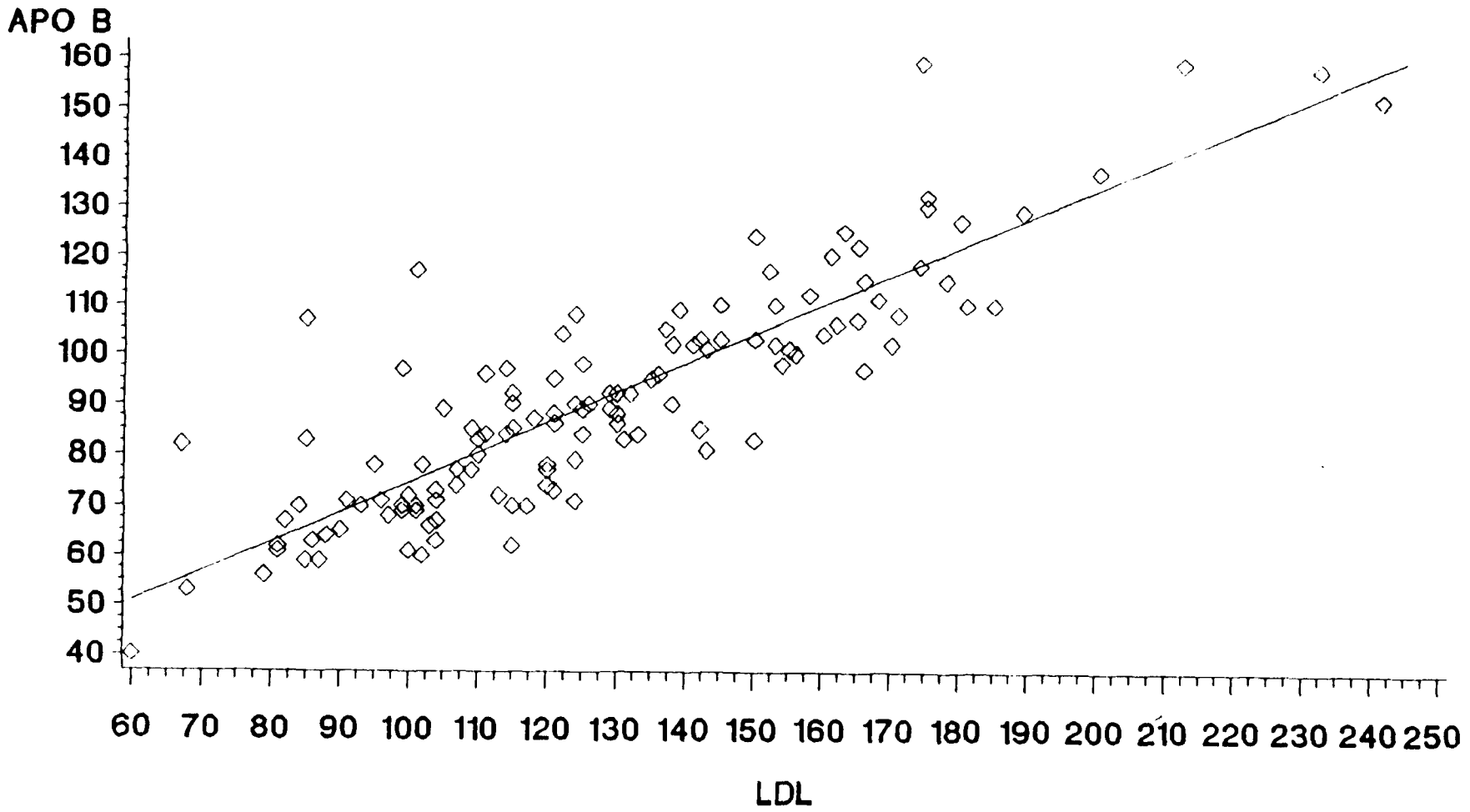
ALL SUBJECTS

Y = 0.59 * X + 15.22

Root MSE = 11.430

r = 0.868 rsquare = 0.753

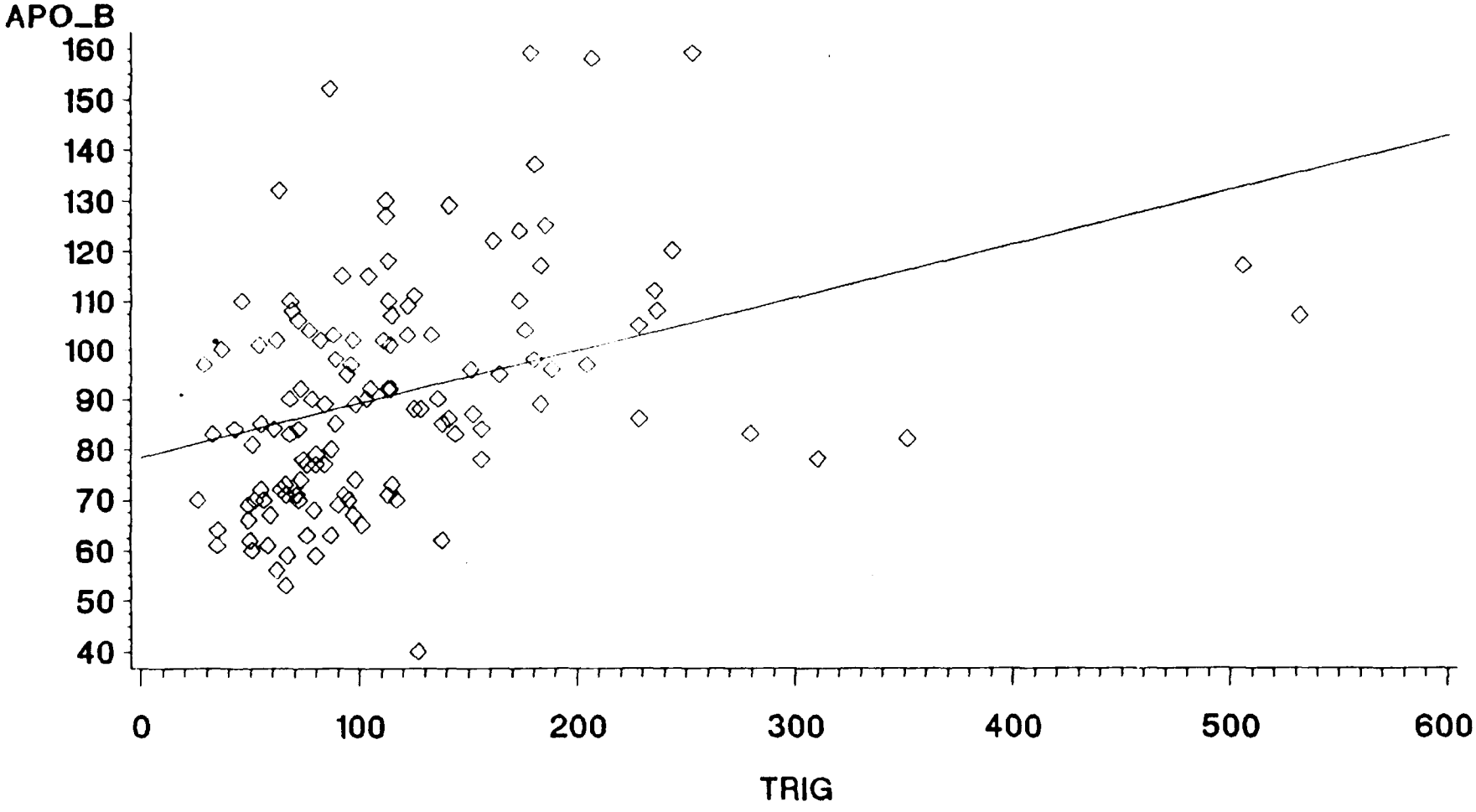
n = 125



114-52

ALL SUBJECTS

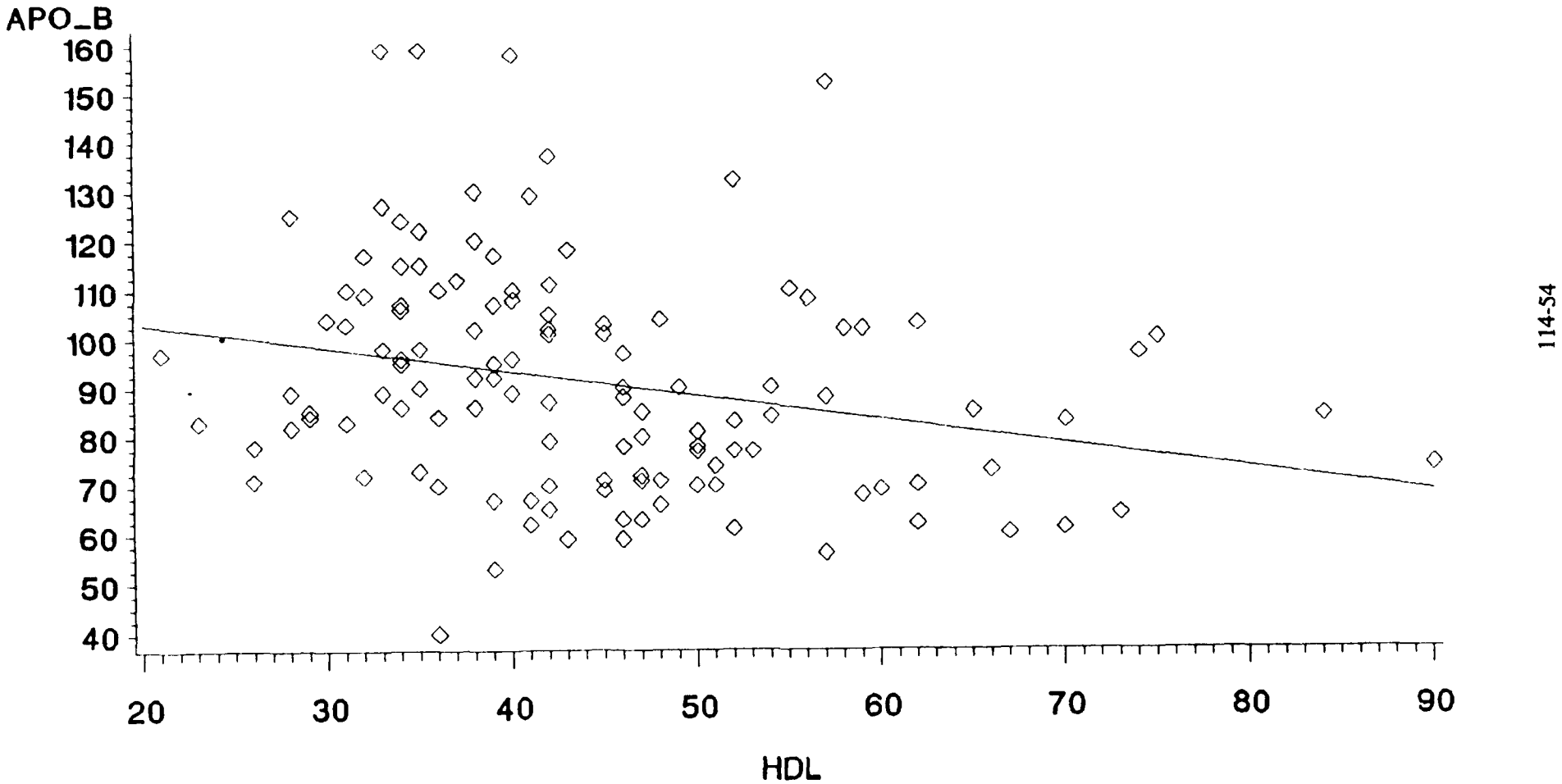
Y = 0.11 * X + 78.45
Root MSE = 21.384
r = 0.370 rsquare = 0.137
n = 125



114-53

ALL SUBJECTS

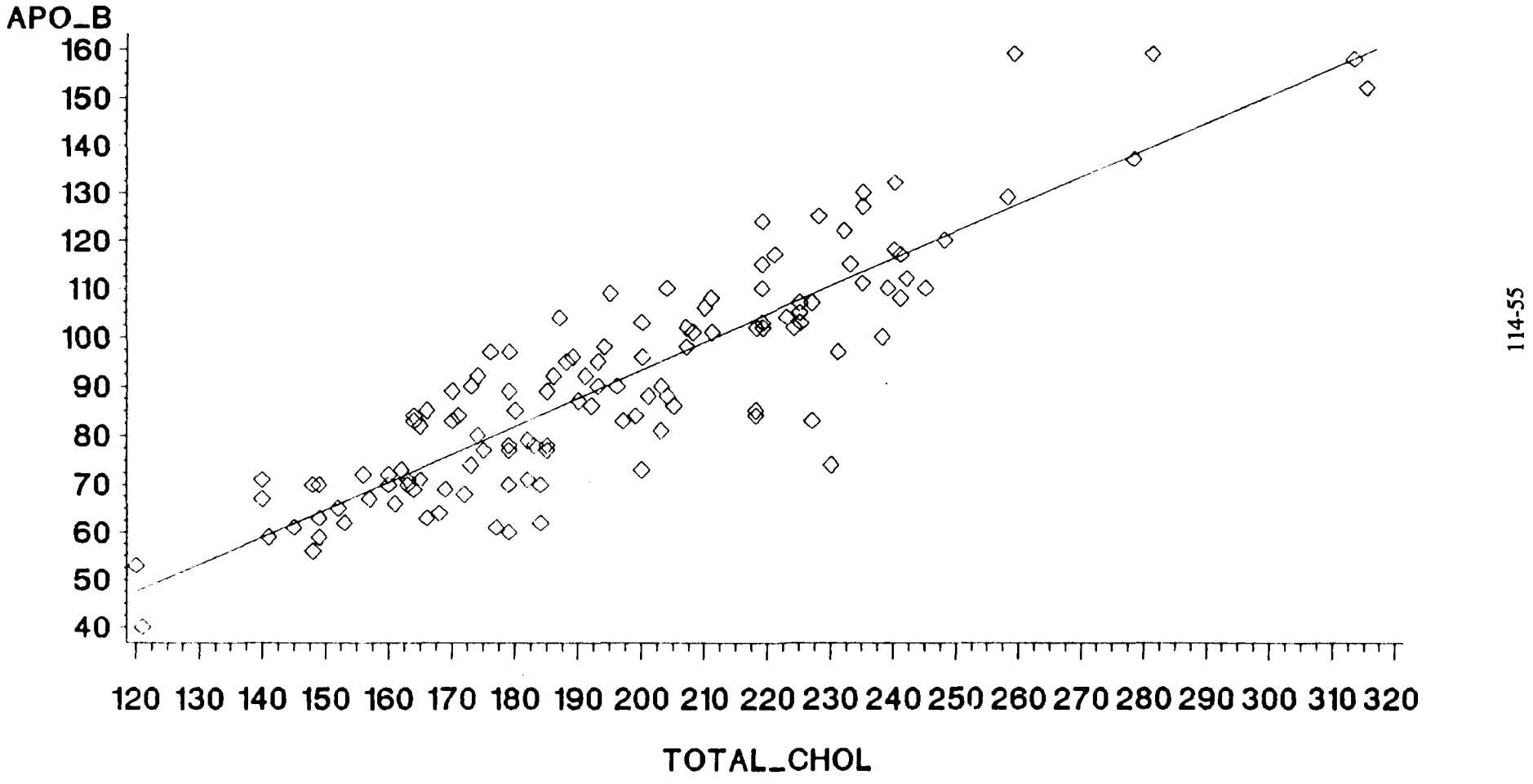
Y = -0.49 * X + 112.9
Root MSE = 22.170
r = -0.268 rsquare = 0.072
n = 125



114-54

ALL SUBJECTS

Y = 0.57 * X + -21.0
Root MSE = 10.549
r = 0.889 rsquare = 0.790
n = 125



114-55

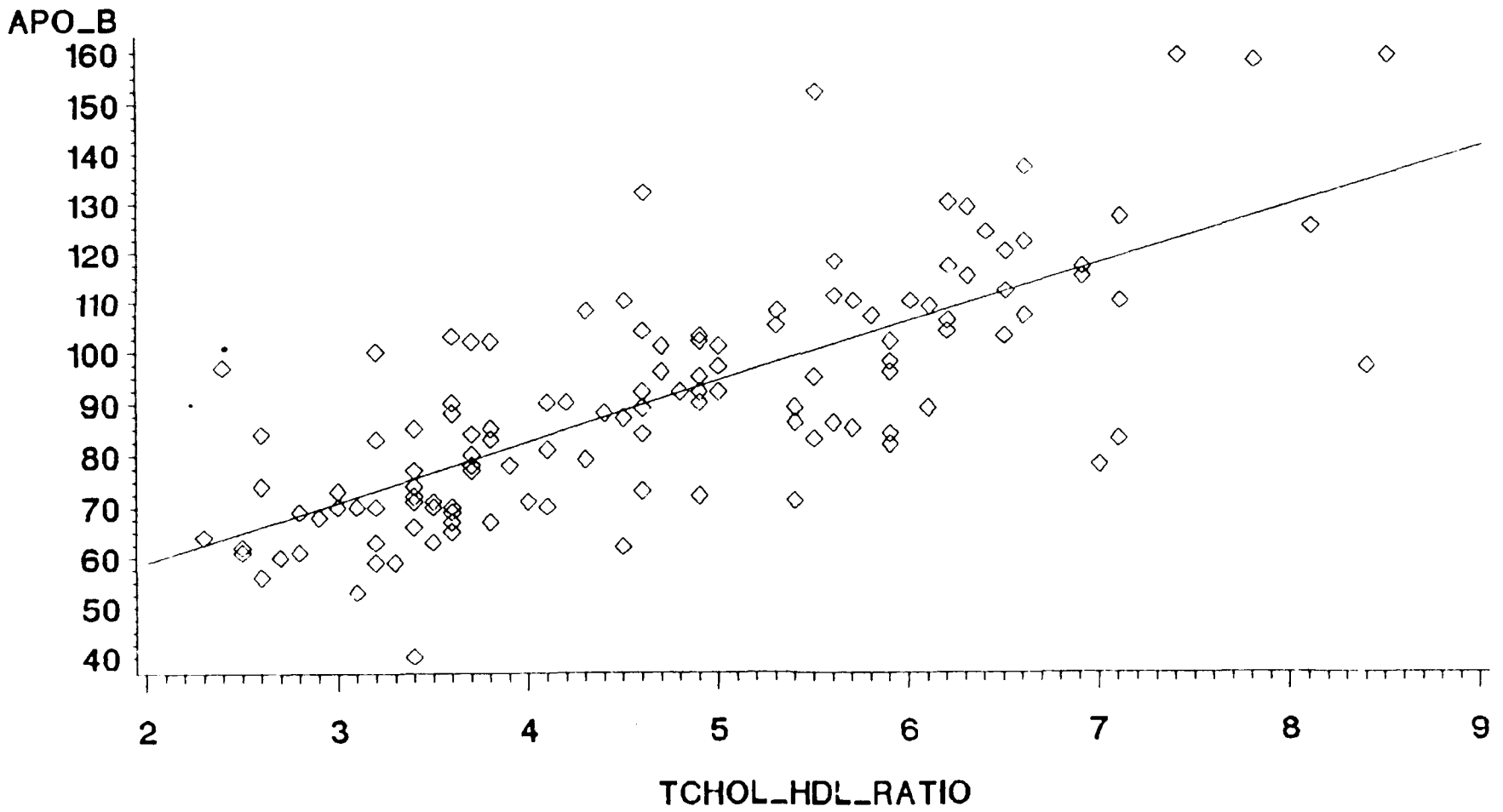
ALL SUBJECTS

Y = 11.78 * X + 35.44

Root MSE = 15.342

r = 0.745 rsquare = 0.556

n = 125



114-56

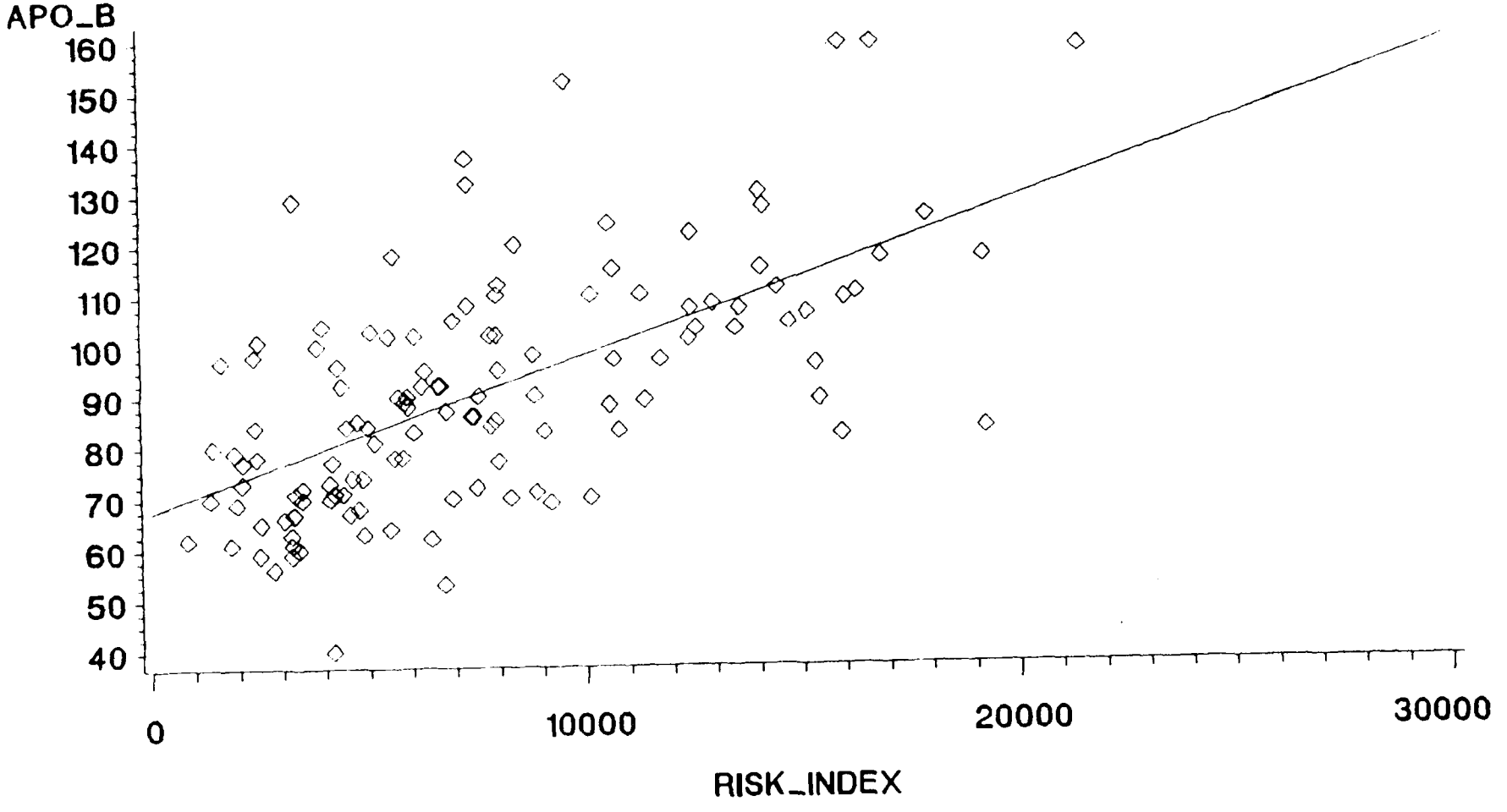
ALL SUBJECTS

Y = 0.00 * X + 67.62

Root MSE = 18.132

r = 0.616 rsquare = 0.379

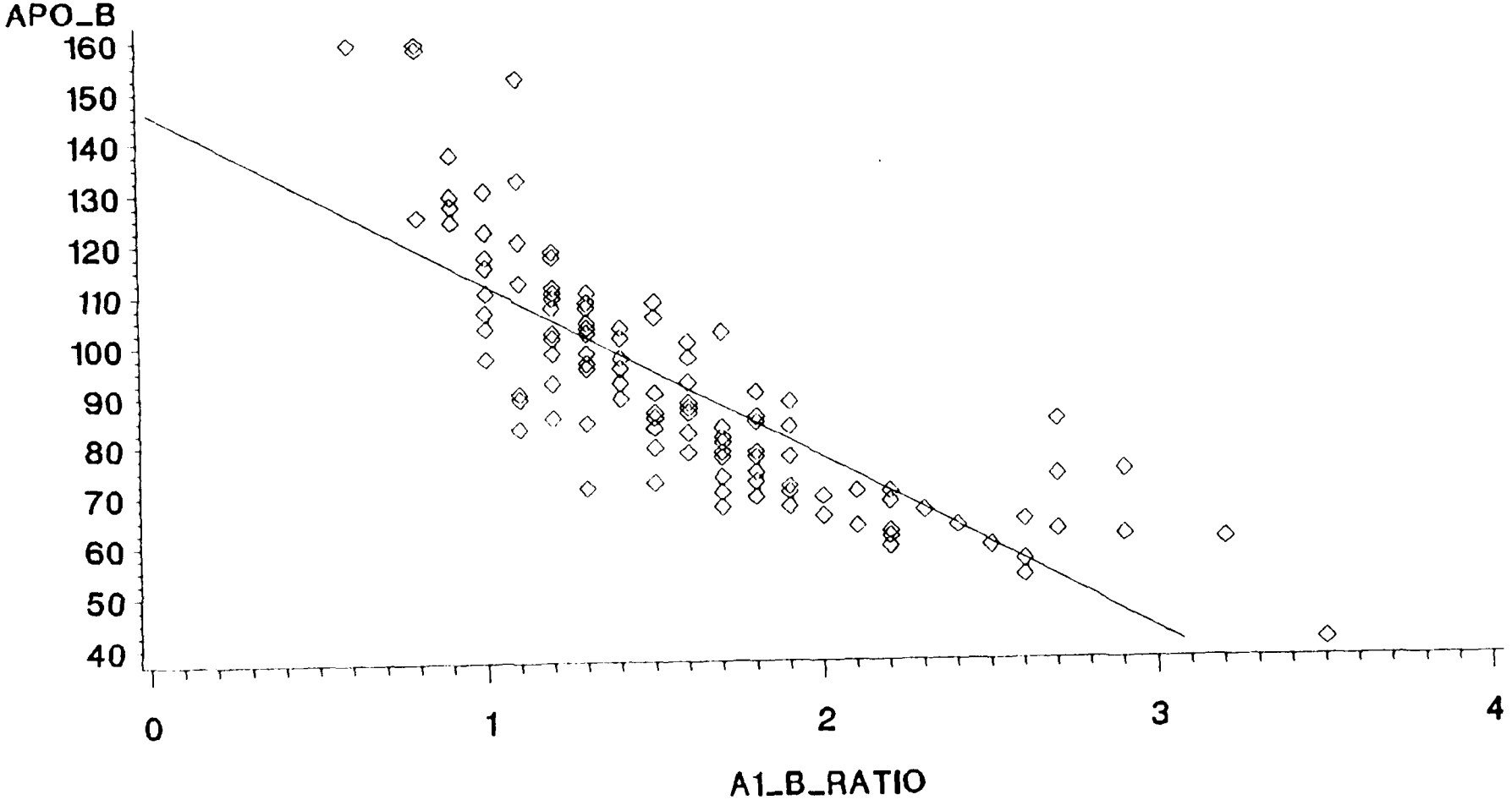
n = 125



114-57

ALL SUBJECTS

Y = -34.5 * X + 146.0
Root MSE = 13.414
r = -0.813 rsquare = 0.660
n = 125



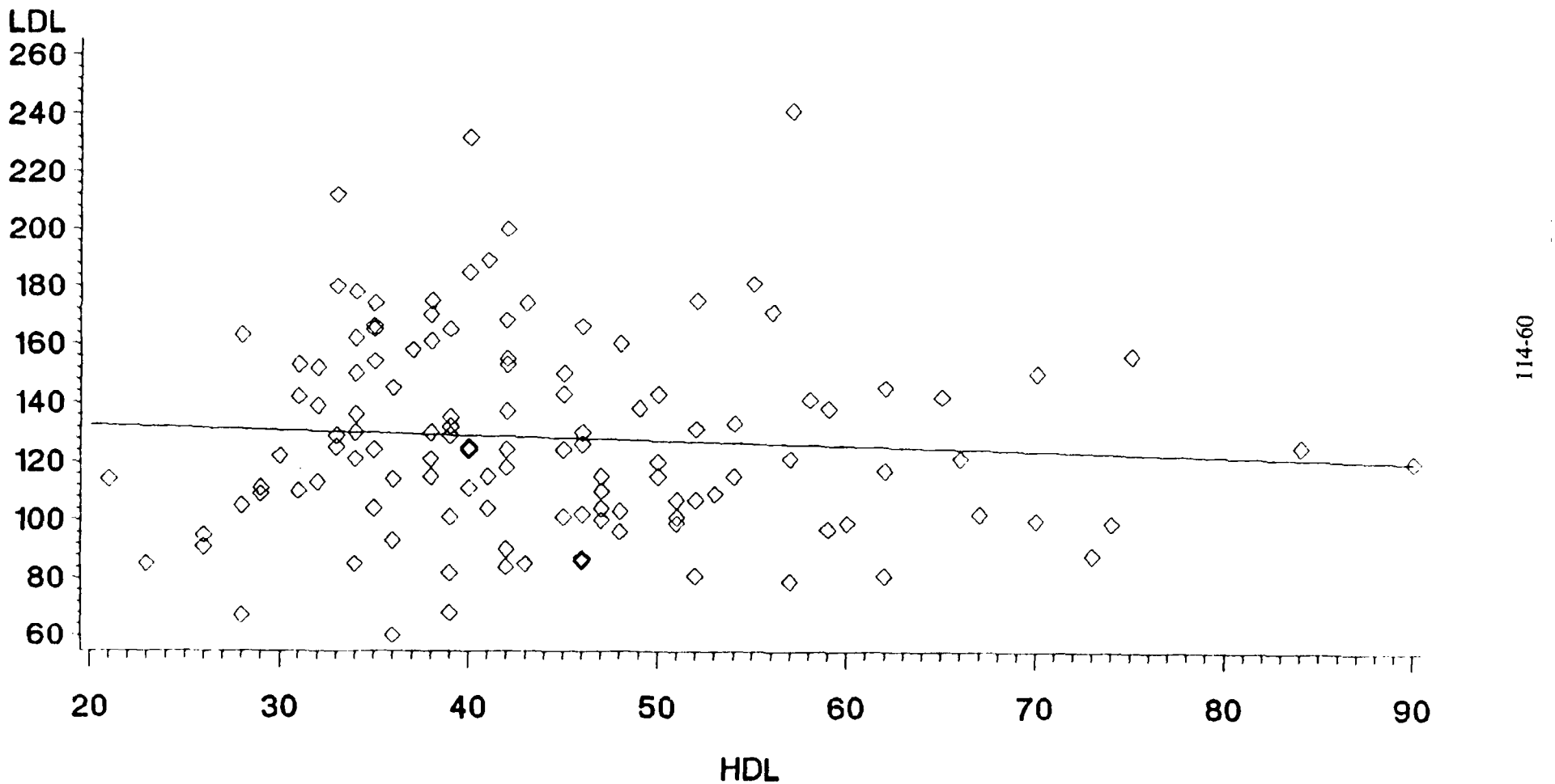
114-58

ALL SUBJECTS

Y = -0.00 * X + 128.6
Root MSE = 33.732
r = -0.010 rsquare = 0.000
n = 125

ALL SUBJECTS

Y = -0.18 * X + 136.1
Root MSE = 33.657
r = -0.067 rsquare = 0.005
n = 125



114-60

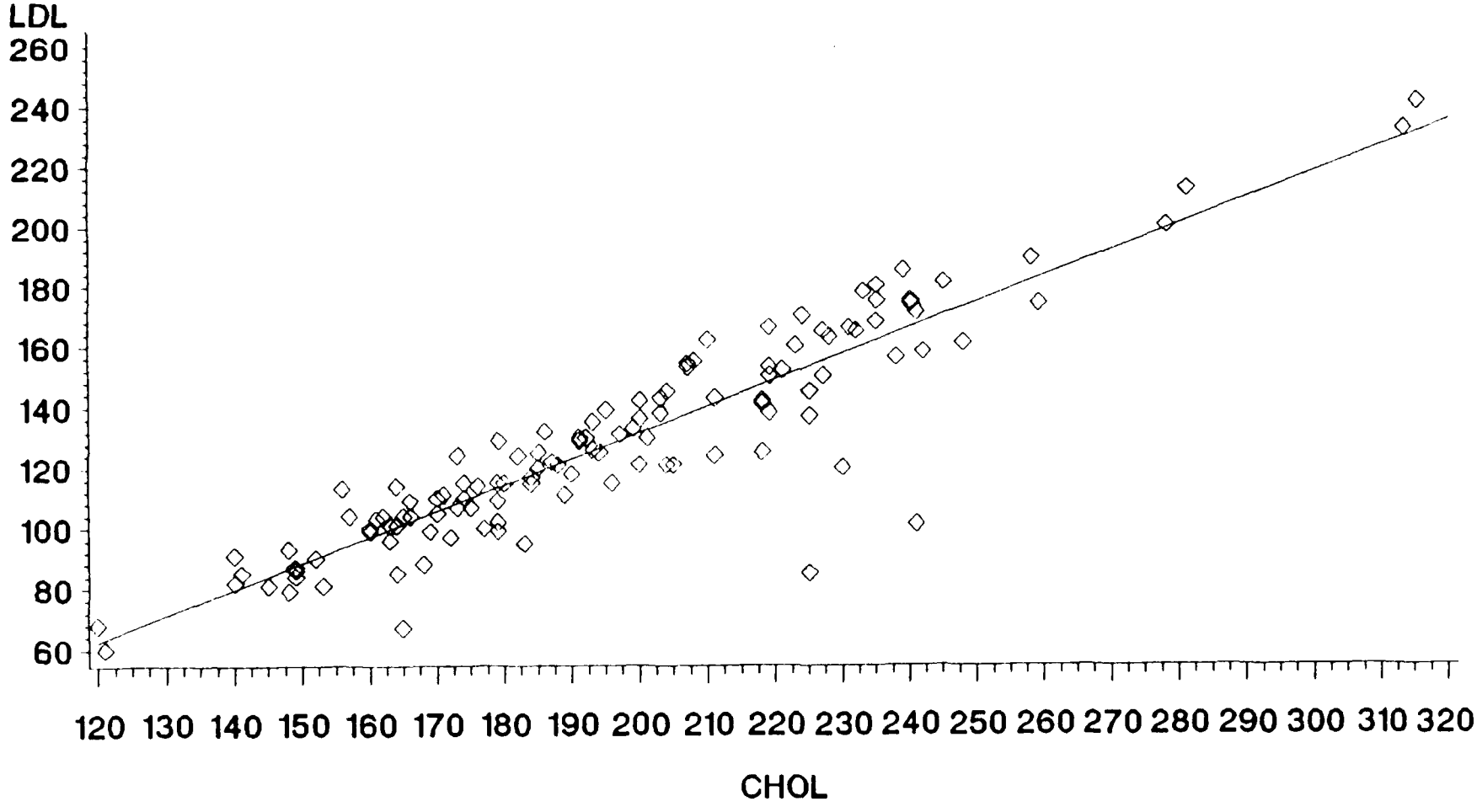
ALL SUBJECTS

Y = 0.86 * X + -41.1

Root MSE = 13.585

r = 0.915 rsquare = 0.838

n = 125



114-61

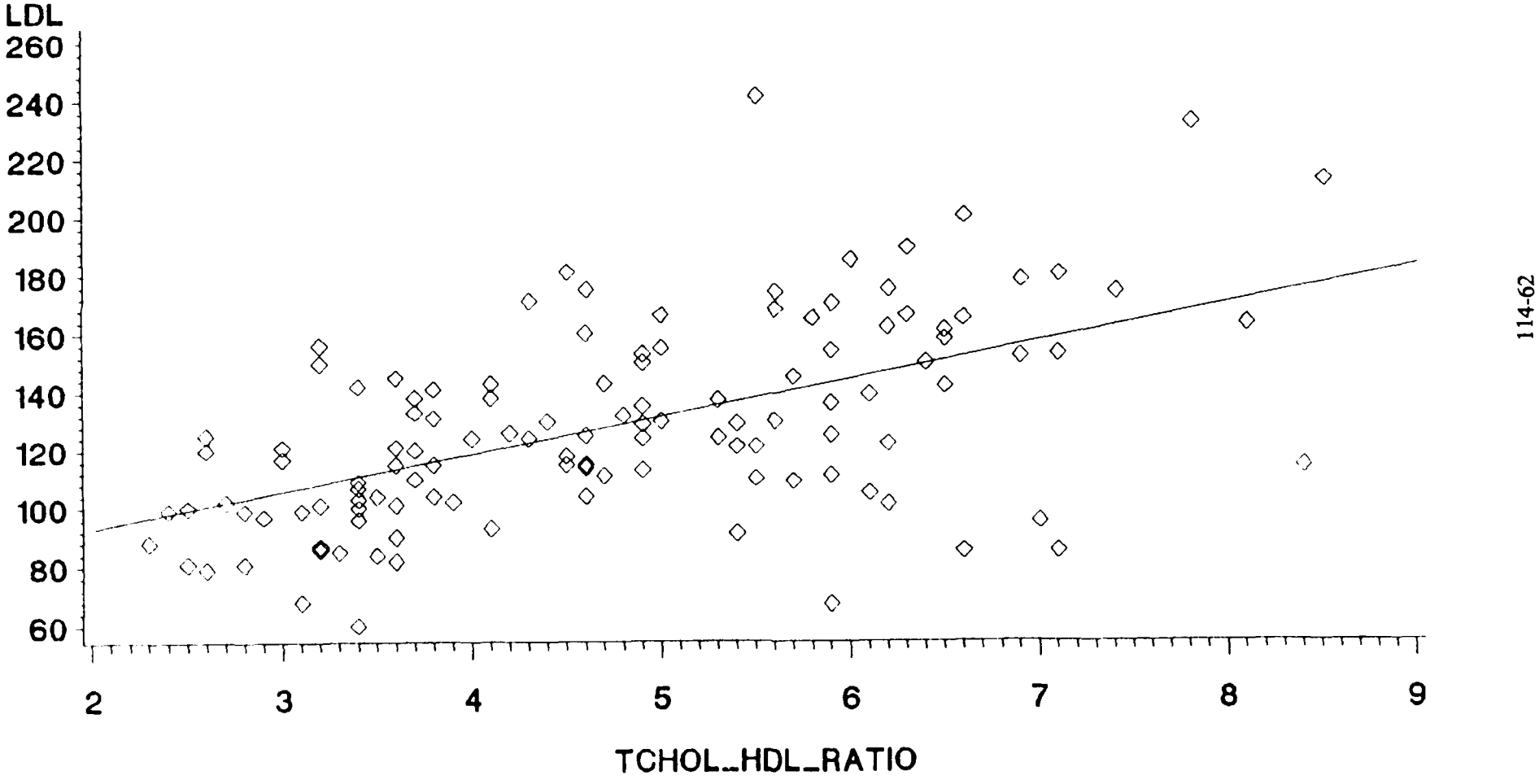
ALL SUBJECTS

Y = 12.86 * X + 67.34

Root MSE = 28.054

r = 0.555 rsquare = 0.308

n = 125



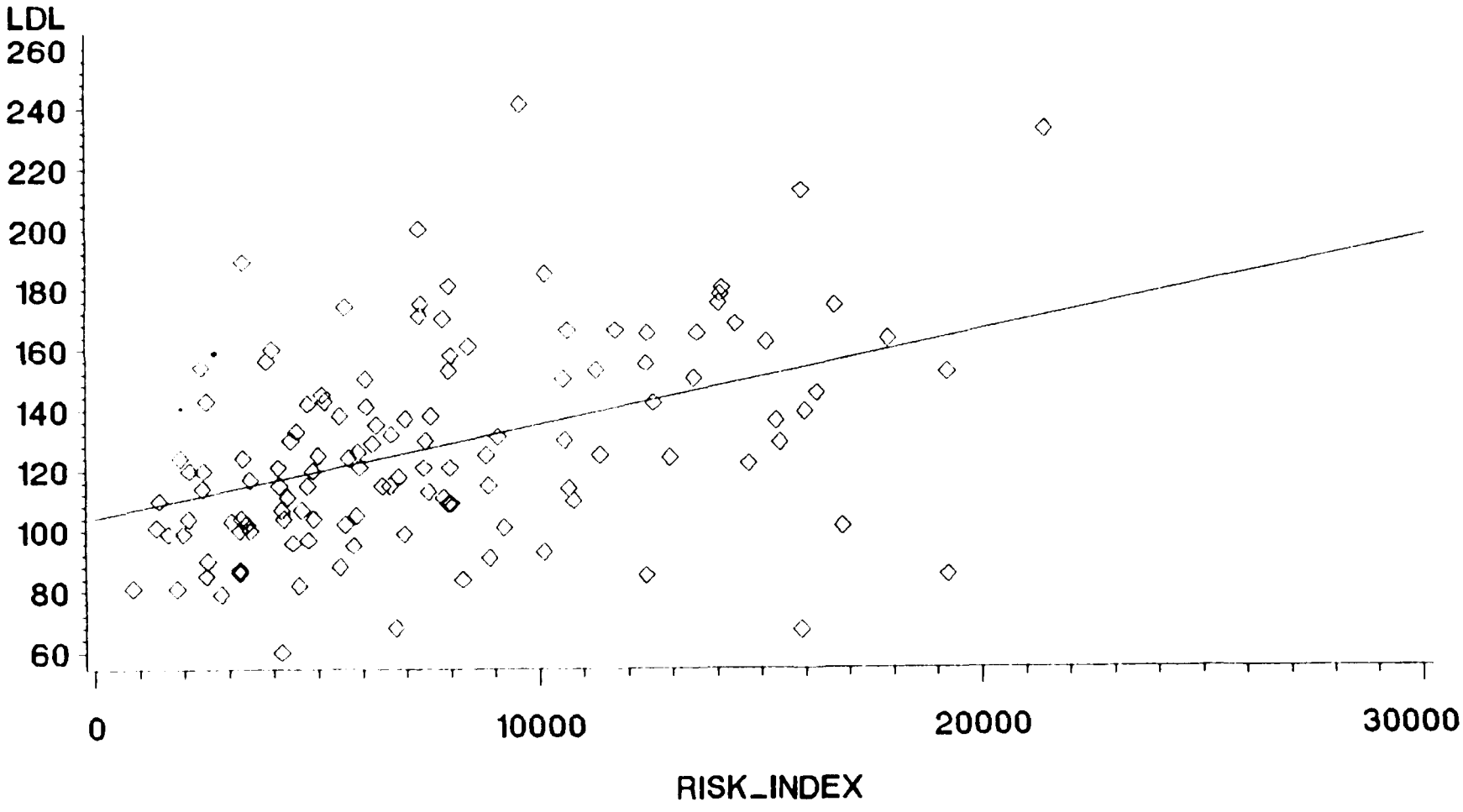
ALL SUBJECTS

Y = 0.00 * X + 104.4

Root MSE = 30.538

r = 0.425 rsquare = 0.180

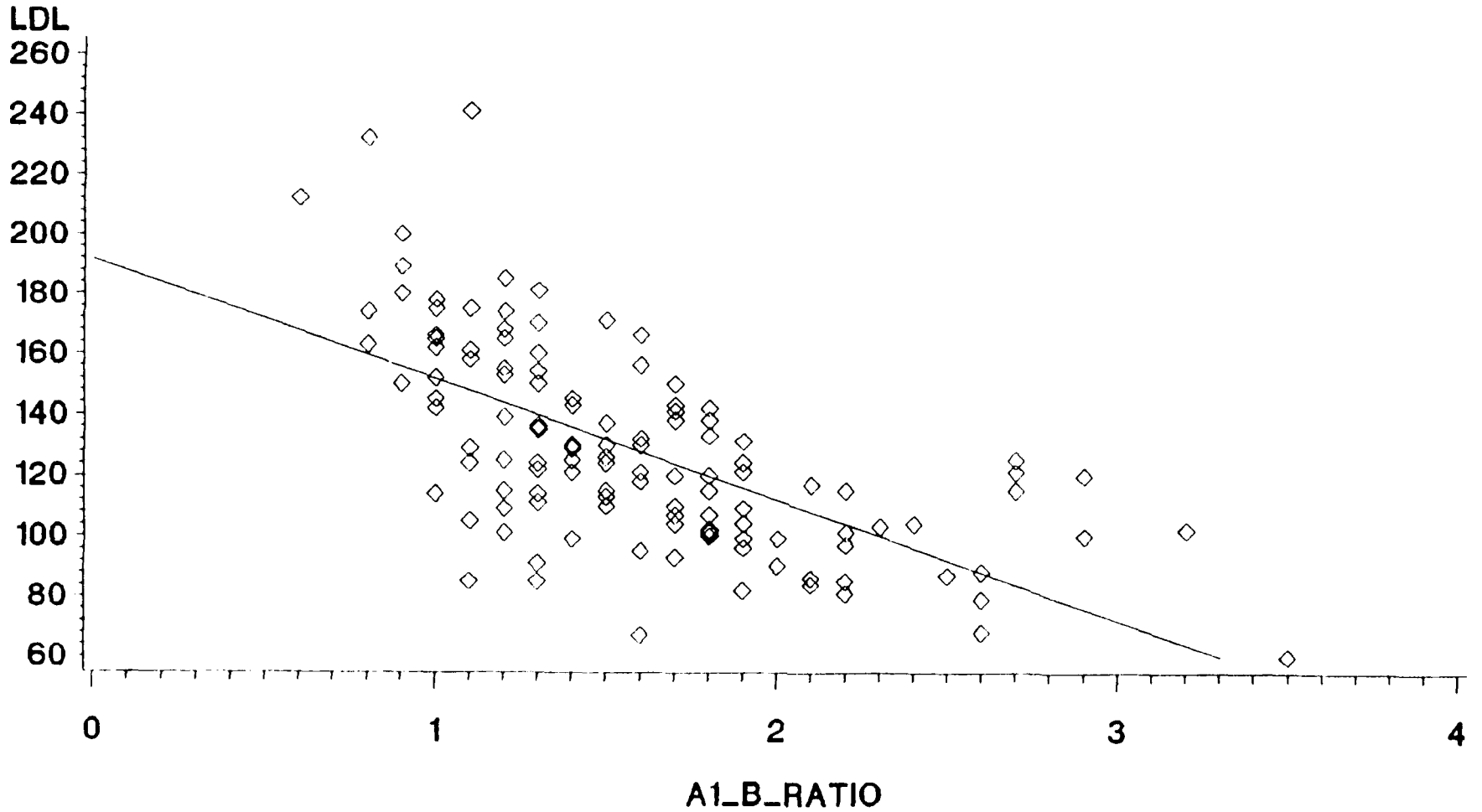
n = 125



114-63

ALL SUBJECTS

Y = -39.7 * X + 191.4
Root MSE = 25.945
r = -0.639 rsquare = 0.408
n = 125



114-64

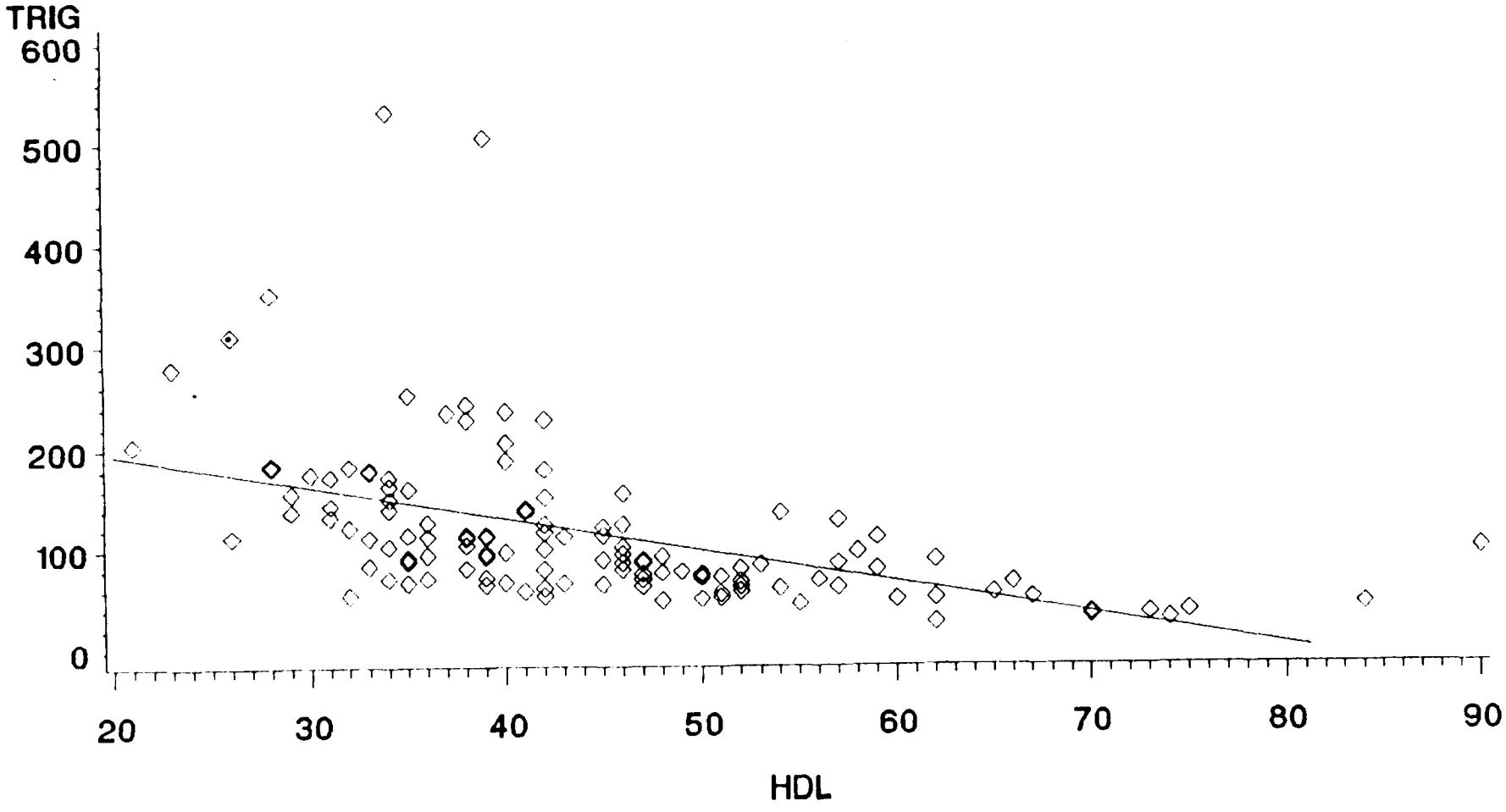
ALL SUBJECTS

Y = -3.19 * X + 259.0

Root MSE = 68.479

r = -0.504 rsquare = 0.254

n = 125



114-65

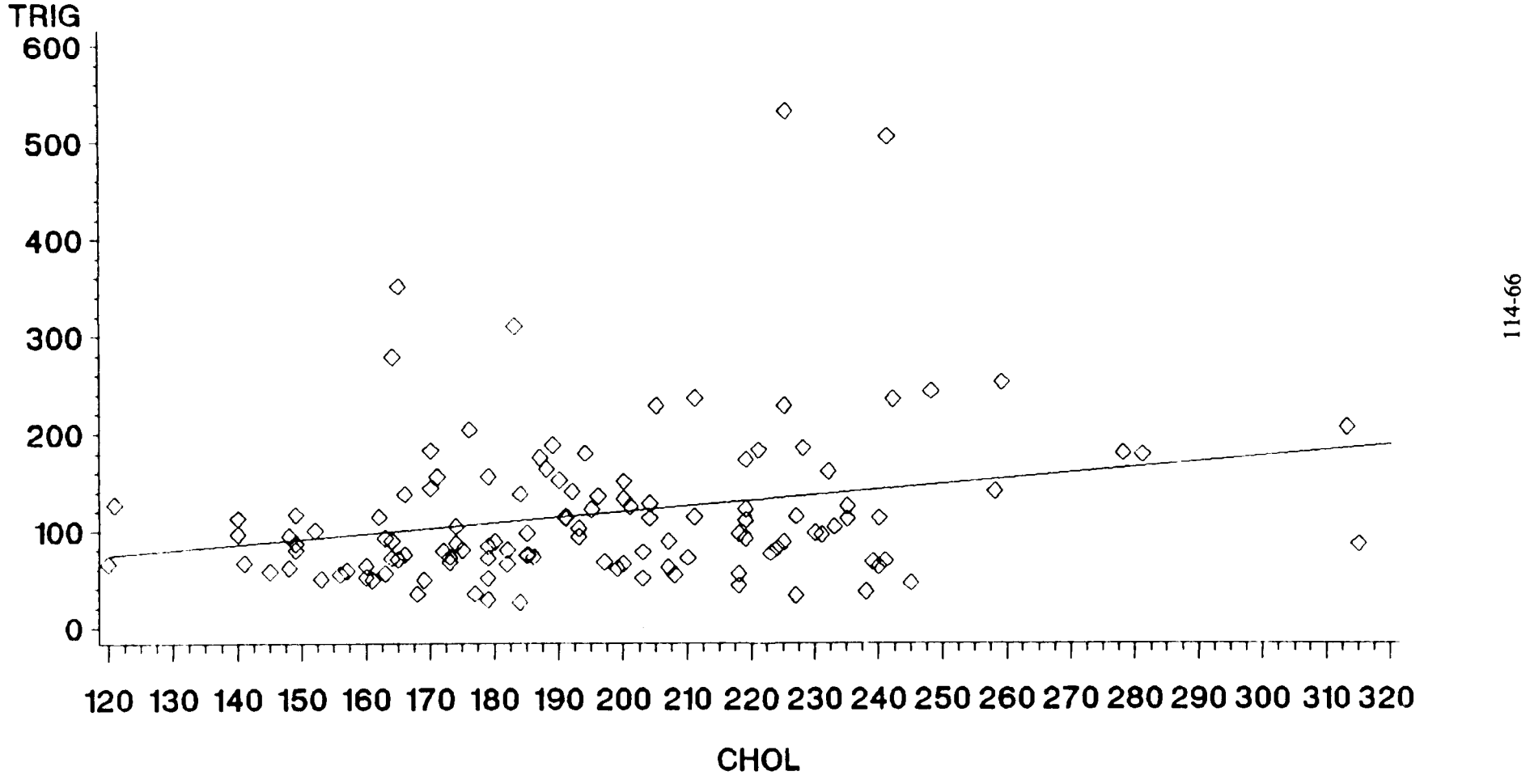
ALL SUBJECTS

Y = 0.57 * X + 5.42

Root MSE = 76.597

r = 0.258 rsquare = 0.066

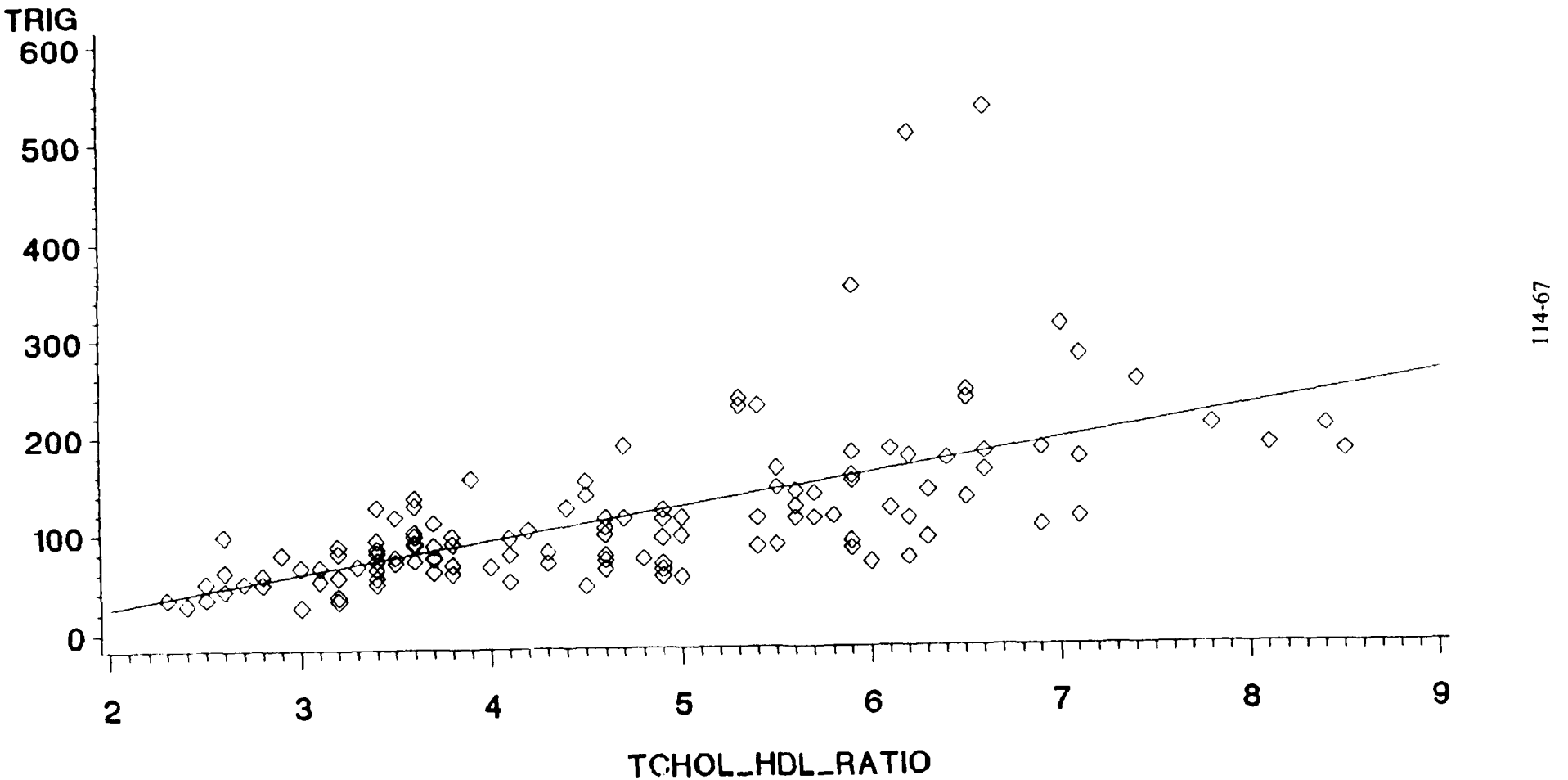
n = 125



114-66

ALL SUBJECTS

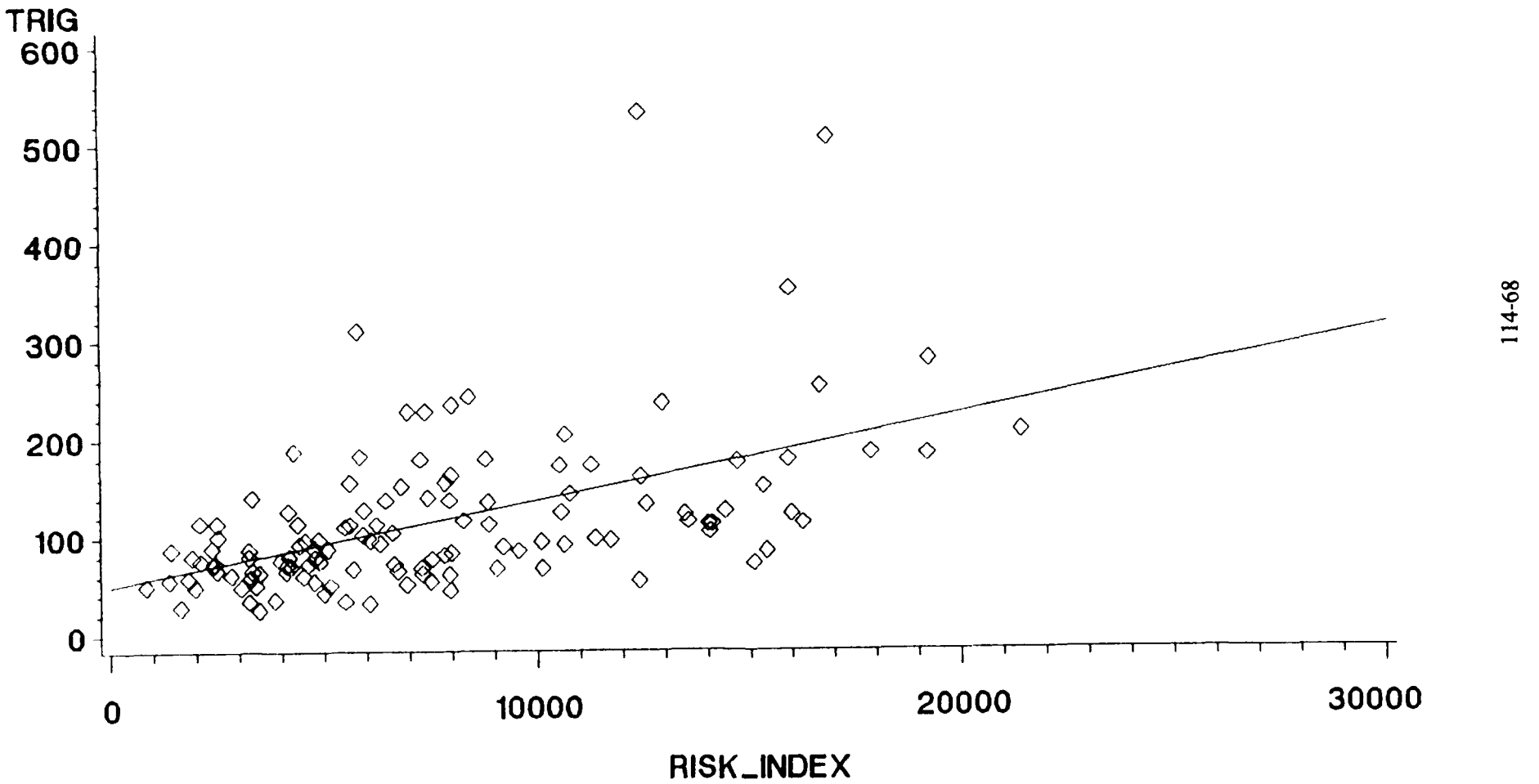
Y = 33.48 * X + -40.7
Root MSE = 62.498
r = 0.615 rsquare = 0.379
n = 125



114-67

ALL SUBJECTS

Y = 0.01 * X + 50.59
Root MSE = 68.201
r = 0.510 rsquare = 0.260
n = 125



114-68

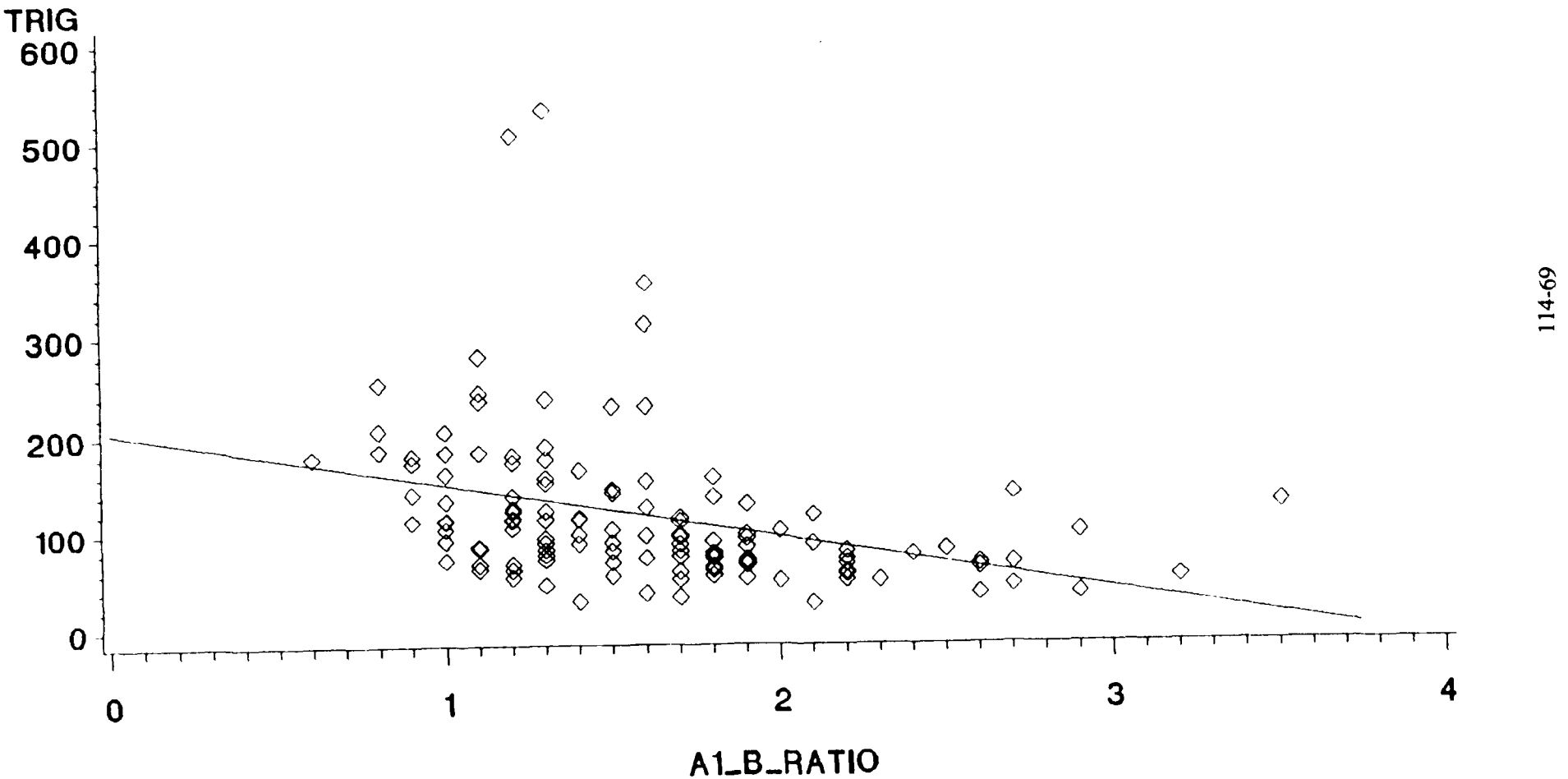
ALL SUBJECTS

Y = -54.6 * X + 204.4

Root MSE = 73.530

r = -0.374 rsquare = 0.140

n = 125



114-69

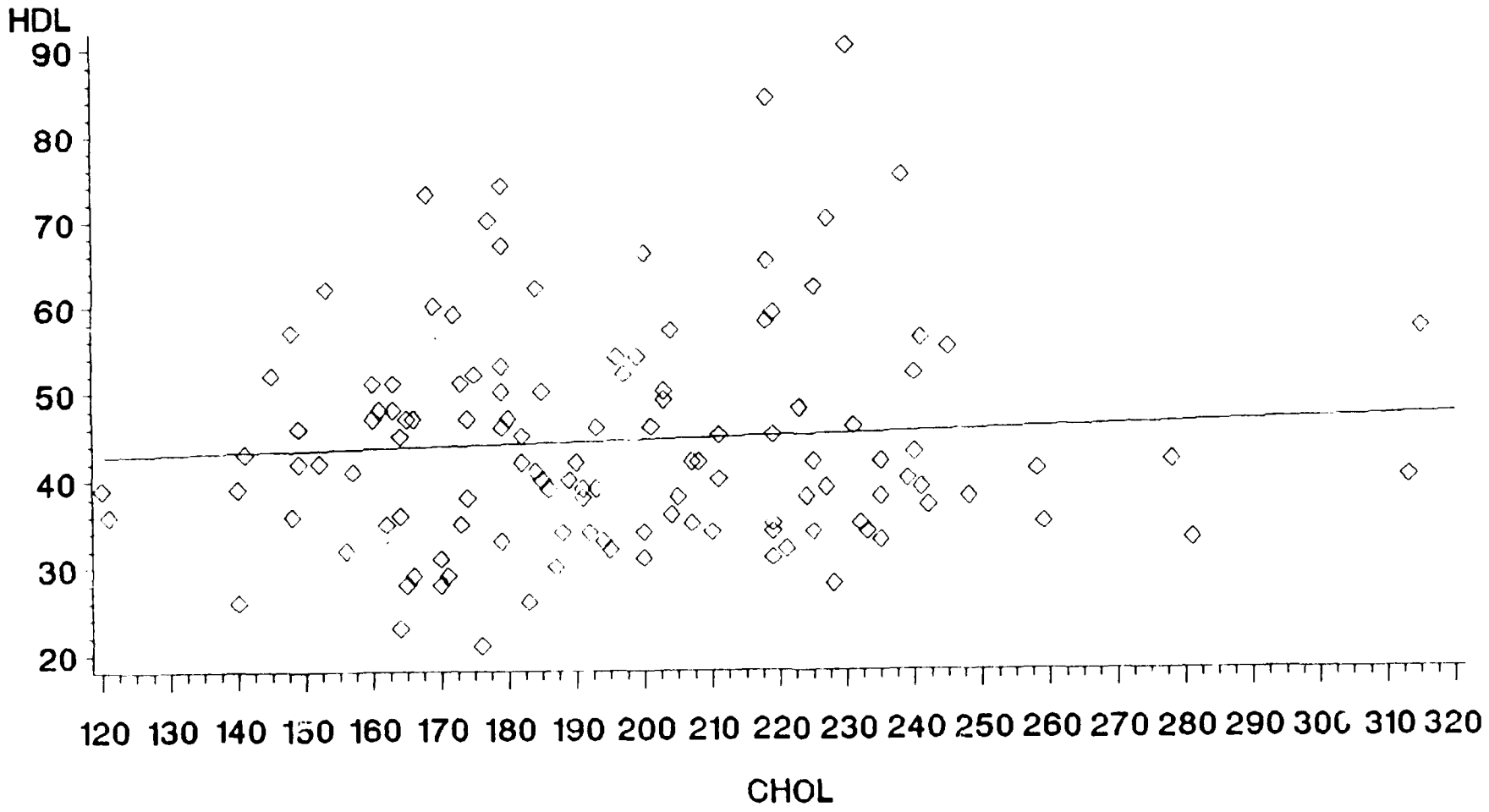
ALL SUBJECTS

Y = 0.02 * X + 40.06

Root MSE = 12.503

r = 0.063 rsquare = 0.004

n = 125



114-70

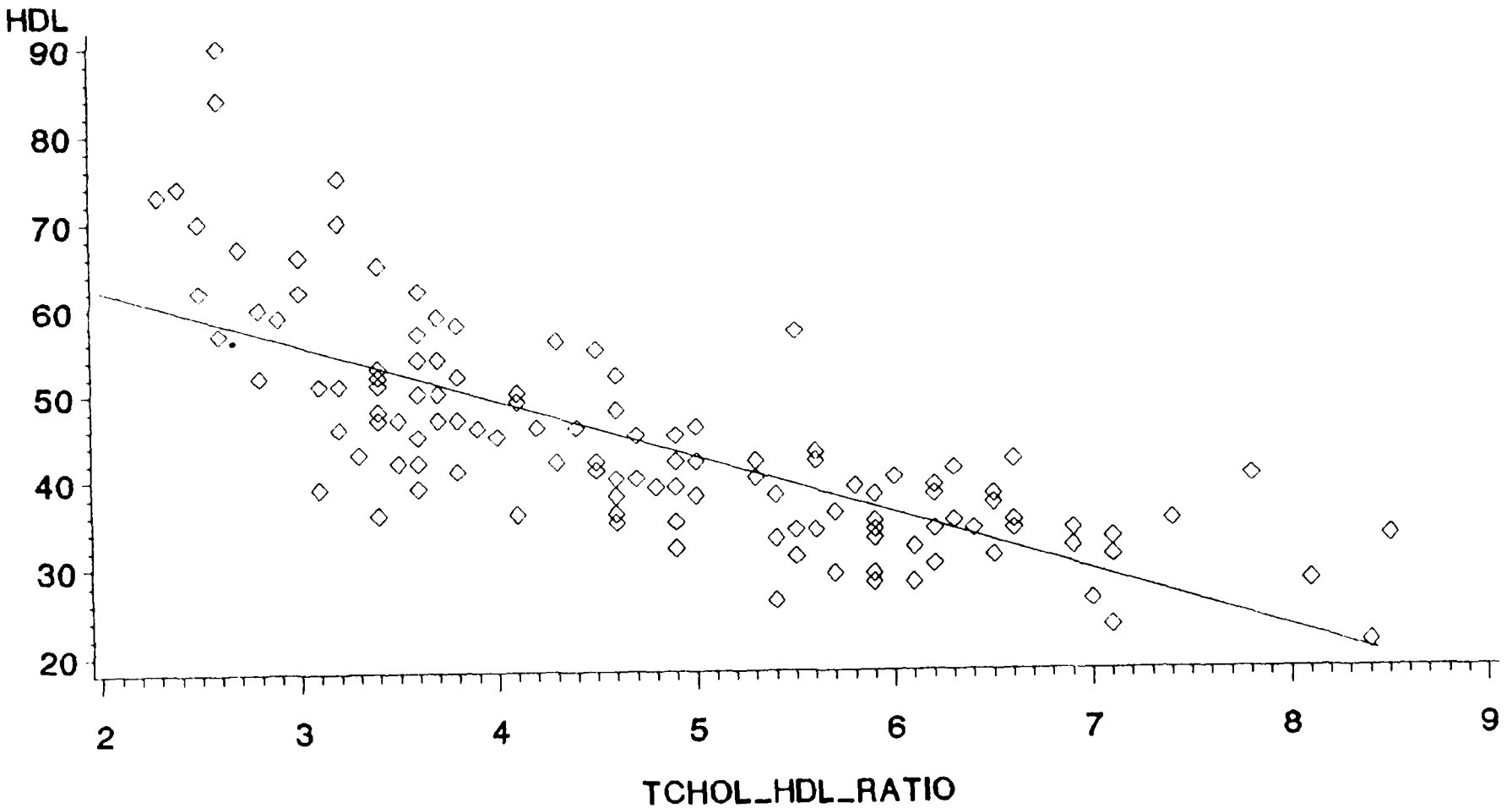
ALL SUBJECTS

Y = -6.58 * X + 75.47

Root MSE = 8.068

r = -0.765 rsquare = 0.585

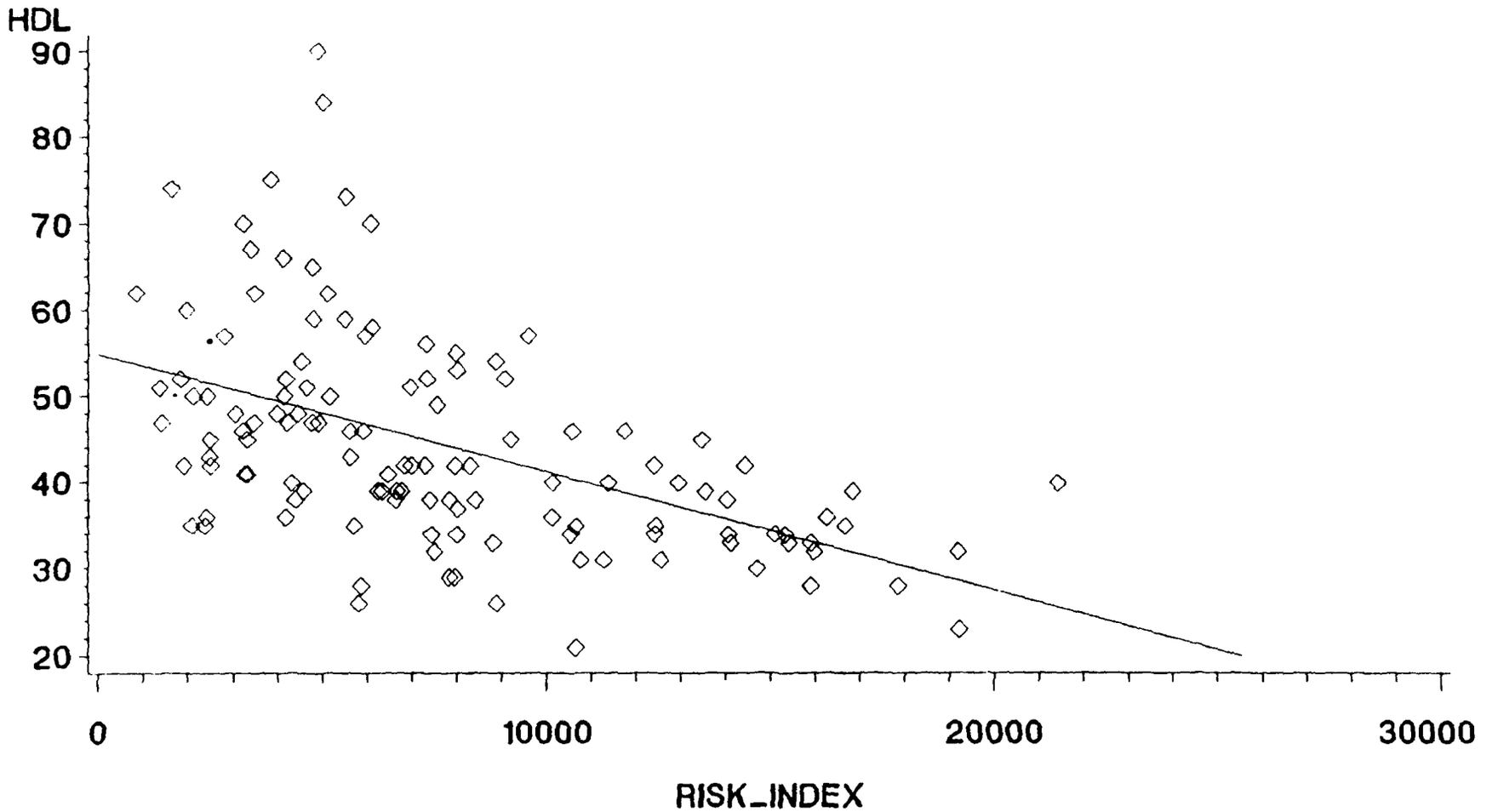
n = 125



114-71

ALL SUBJECTS

Y = -0.00 * X + 54.89
Root MSE = 10.803
r = -0.506 rsquare = 0.256
n = 125



114-72

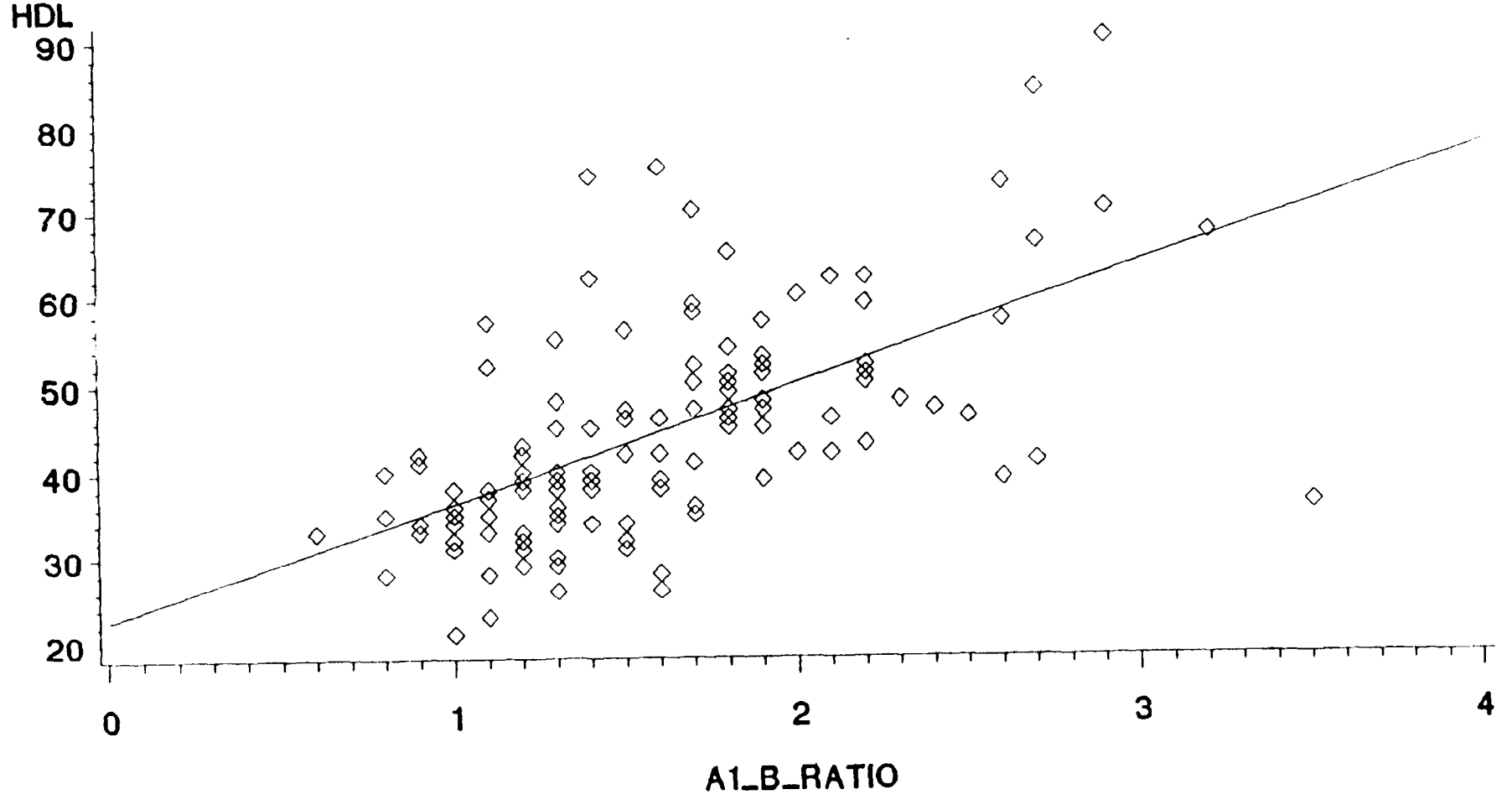
ALL SUBJECTS

Y = 13.63 * X + 22.69

Root MSE = 10.114

r = 0.590 rsquare = 0.348

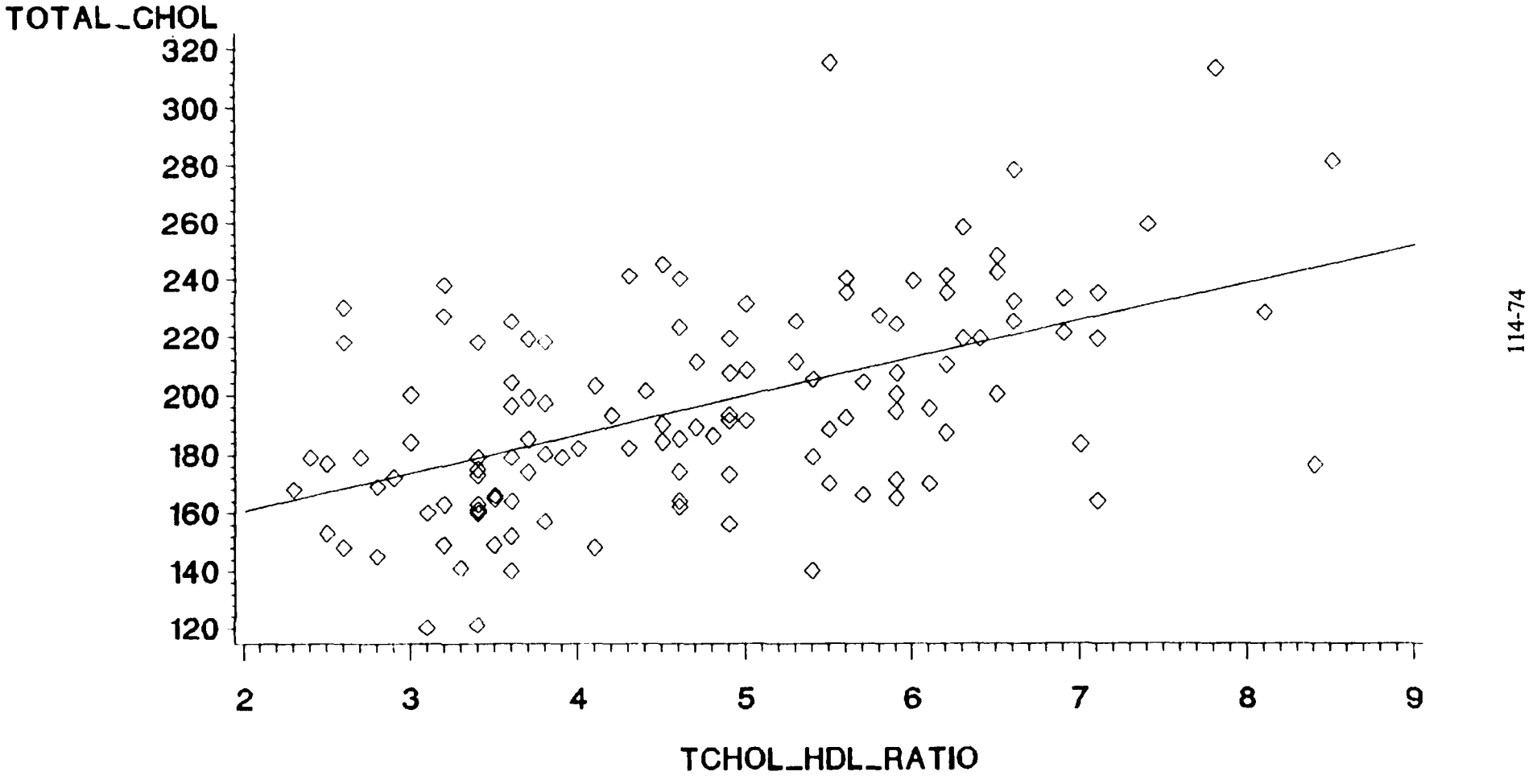
n = 125



114-73

ALL SUBJECTS

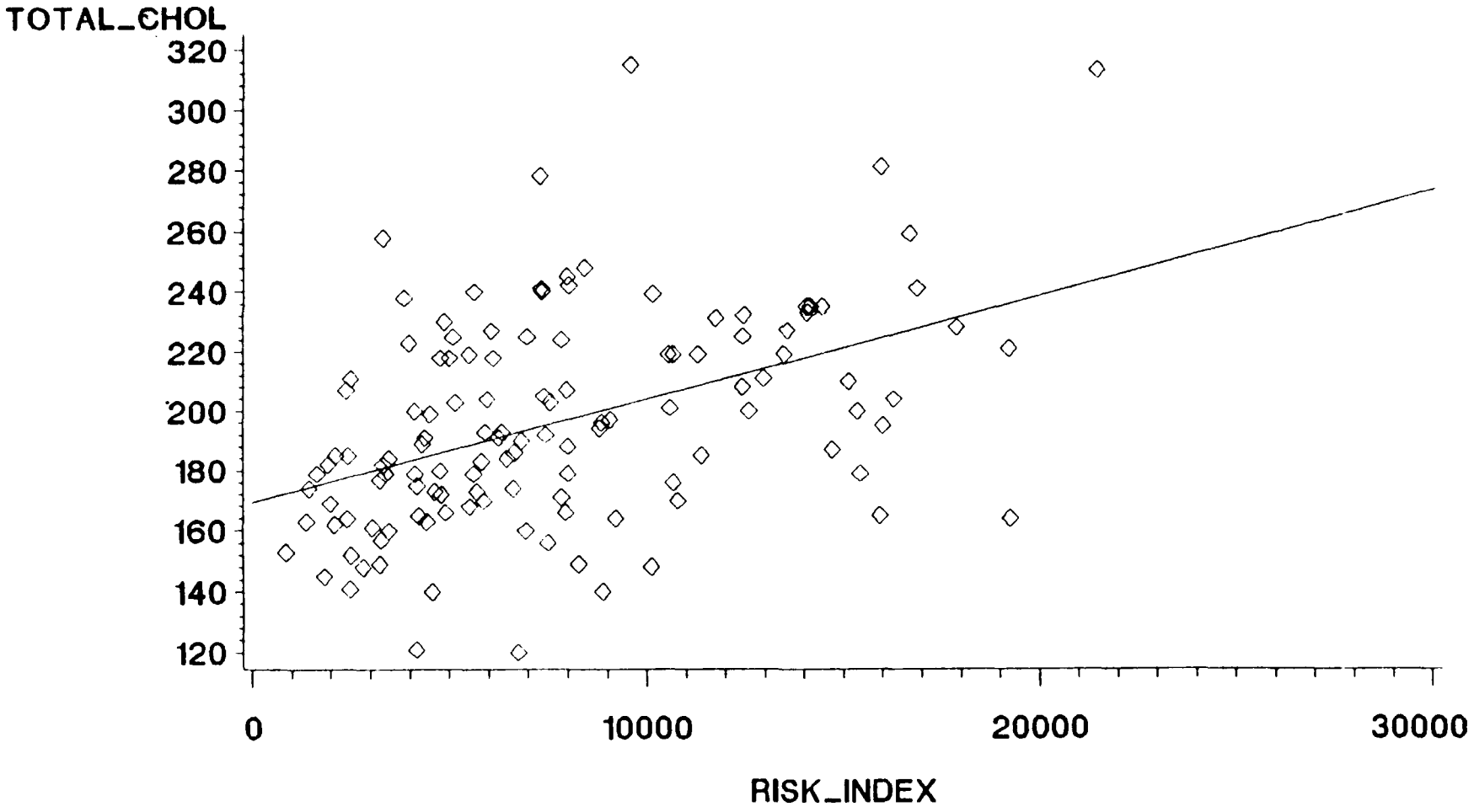
Y = 12.99 * X + 134.6
Root MSE = 30.357
r = 0.529 rsquare = 0.280
n = 125



114-74

ALL SUBJECTS

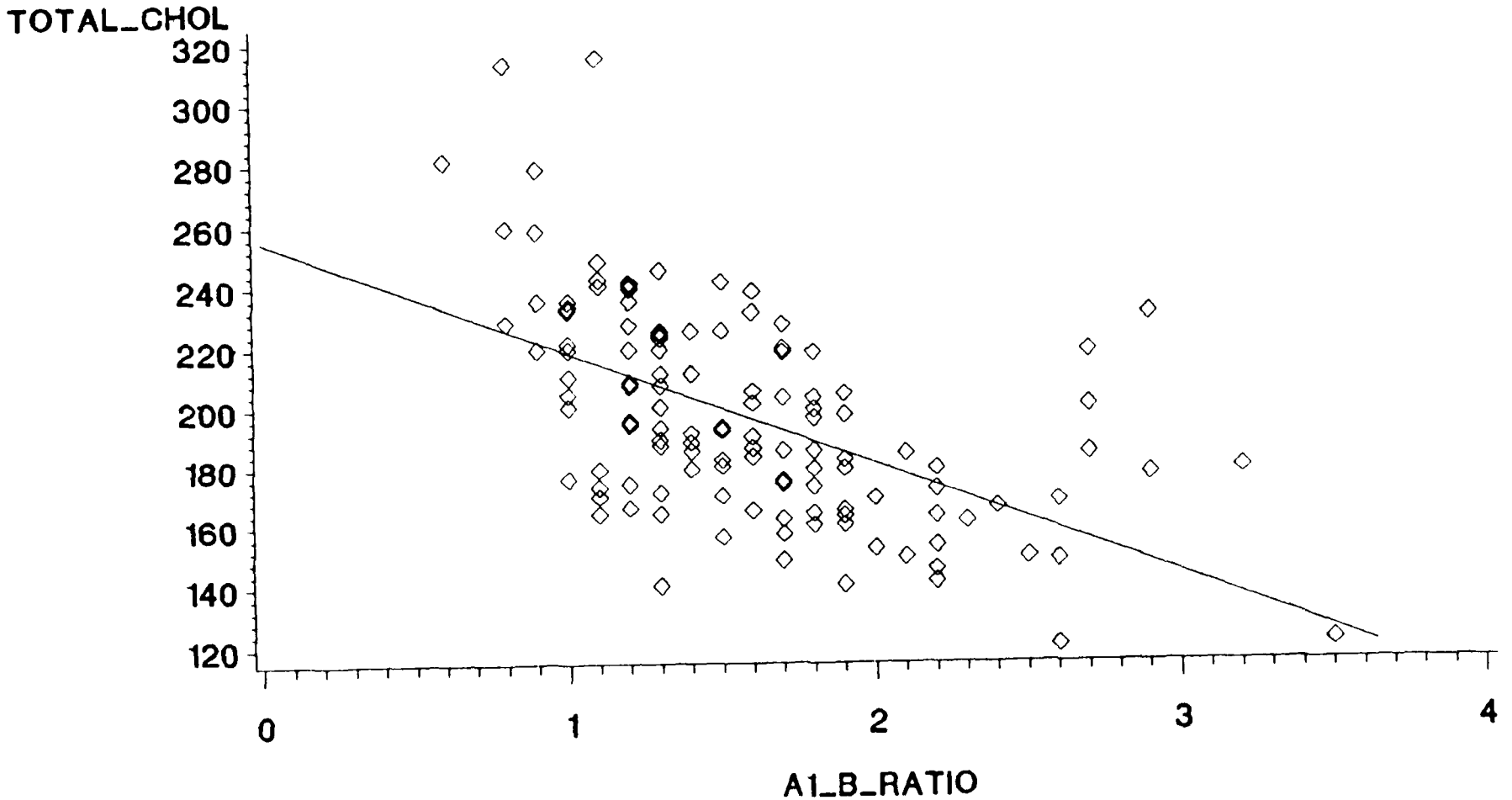
Y = 0.00 * X + 169.4
Root MSE = 31.961
r = 0.449 rsquare = 0.202
n = 125



114-75

ALL SUBJECTS

Y = -37.1 * X + 255.1
Root MSE = 29.573
r = -0.563 rsquare = 0.317
n = 125



114-76

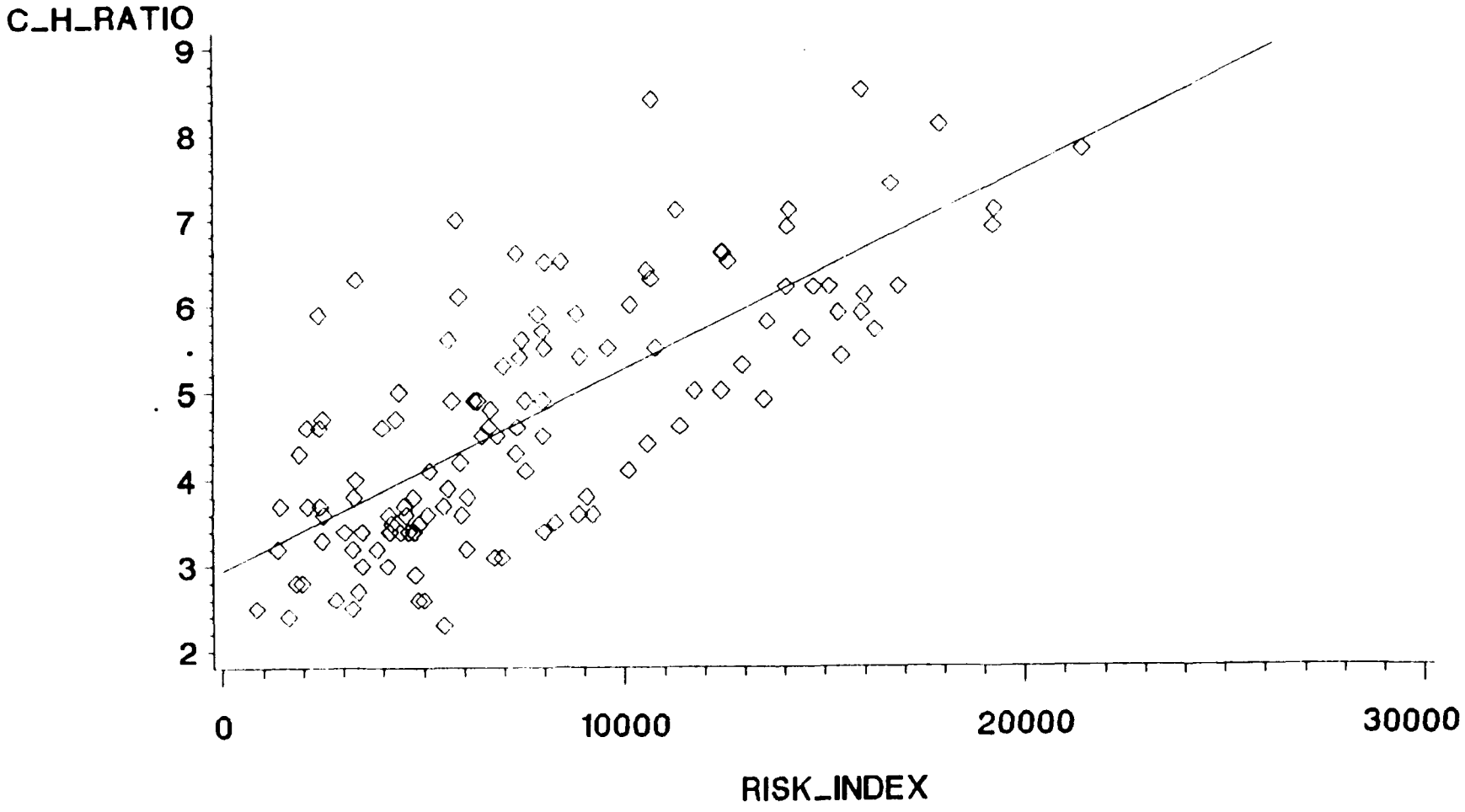
ALL SUBJECTS

Y = 0.00 * X + 2.95

Root MSE = 0.984

r = 0.737 rsquare = 0.544

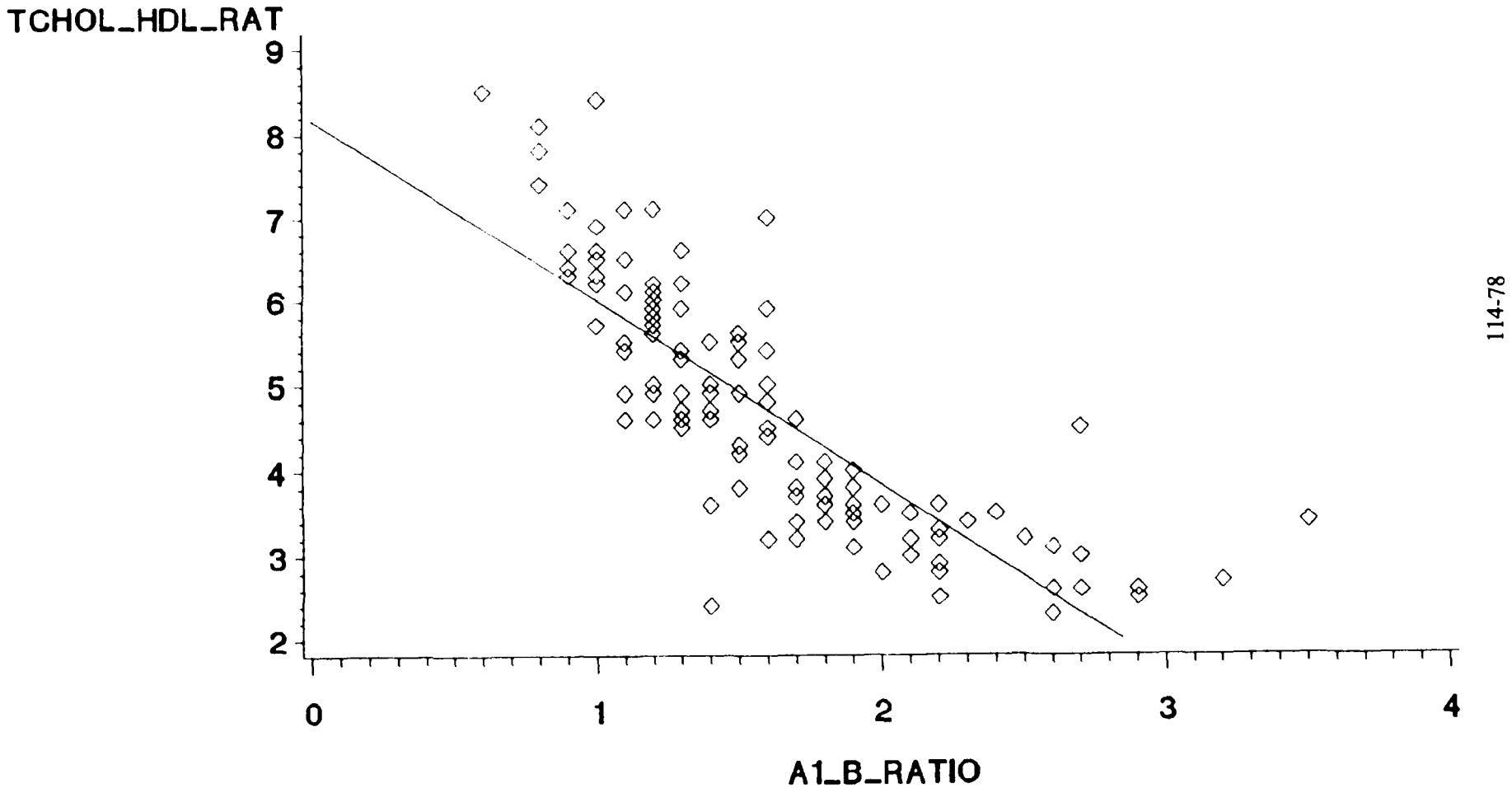
n = 125



114-77

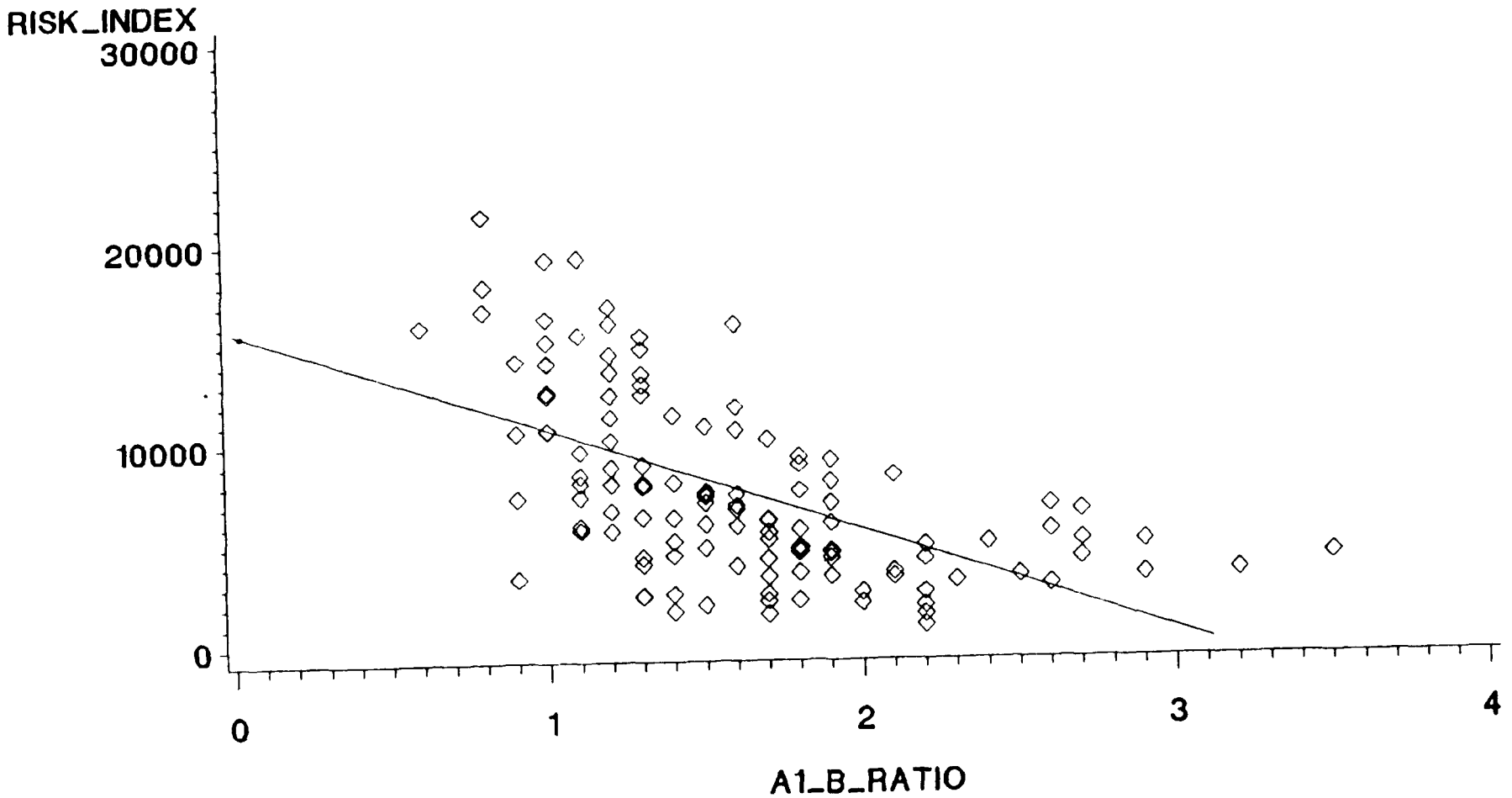
ALL SUBJECTS

Y = -2.17 * X + 8.18
Root MSE = 0.858
r = -0.808 rsquare = 0.653
n = 125



ALL SUBJECTS

Y = -5048 * X + 15720
Root MSE = 3753.9
r = -0.589 rsquare = 0.347
n = 125



114-79

CAD PREDICTION STUDY GRAPH ANALYSIS

GRAPH 1 APOLIPOPROTEIN A-1 VS. APOLIPOPROTEIN B THIS GRAPH SHOWS THAT THERE IS NO DEPENDENCE OF ONE APOLIPOPROTEIN UPON ANOTHER. THERE IS NO RELATIONSHIP BETWEEN THESE VALUES. THIS IS EXPECTED. APO A-1 IS THE MAIN APOLIPOPROTEIN OF HDL, WHILE APO B IS CONCENTRATED IN LDL. THERE IS NO BIOLOGICAL OR CHEMICAL DEPENDENCE OF ONE UPON THE OTHER.

GRAPH 2 APO A-1 VS. LDL CHOLESTEROL THIS GRAPH SHOWS THAT THERE IS NO CORRELATION BETWEEN APO A-1 AND LDL CHOL. THIS IS NOT UNUSUAL, HOWEVER, BECAUSE HARDLY ANY APO A-1 IS FOUND IN LDL. APO A-1 IS PREDOMINANTLY LOCATED IN HDL, THEREFORE NOT AFFECTING LDL CHOLESTEROL LEVELS.

GRAPH 3 APO A-1 VS. TRIGLYCERIDES THIS GRAPH REVEALS A LACK OF CORRELATION AMONG APO A-1 AND TRIG. ON THE GRAPH, THE TRIG VALUES ARE CLUMPED PRIMARILY BETWEEN 50 AND 200, WHILE THE APO A-1 VALUES ARE SPREAD FROM 90 TO 225. NO RELATIONSHIP IS EXPECTED, BECAUSE APO A-1 IS A PROTEIN AND TRIG IS A LIPID. ALSO, MOST OF THE TRIG IS IN VLDL, WHILE APO A-1 IS IN HDL.

GRAPH 4 APO A-1 VS. HDL CHOL THERE IS A DEFINITE CORRELATION AMONG APO A-1 AND HDL CHOLESTEROL. A CORRELATION COEFFICIENT OF .813 SHOWS THIS GOOD RELATIONSHIP. THIS IS EXPECTED AS APO A-1 COMPRISES

APPROXIMATELY 25% OF THE HDL GLOBULE BY PERCENT OF PARTICLE MASS. WE CAN SEE AS THE CONCENTRATION OF APO A-1 INCREASES, THE CONCENTRATION OF HDL CHOL INCREASES. THIS SHOWS THAT THE MORE APO A-1 AND HDL CHOL YOU HAVE, THE GREATER NUMBER OF HDL YOU HAVE.

GRAPH 5 APO A-1 VS. TOTAL CHOLESTEROL(TC) THERE IS NO RELATIONSHIP BETWEEN APO A-1 AND TC, AS SHOWN BY THIS GRAPH. APO A-1 IS AN APOLIPOPROTEIN, NOT CHOLESTEROL, AND THEREFORE DOES NOT FACTOR INTO THE TOTAL CHOLESTEROL VALUE. ALTHOUGH AN INCREASED AMOUNT OF APO A-1 WOULD BE LIKELY TO INDICATE AN INCREASED AMOUNT OF HDL CHOLESTEROL, THIS WOULD NOT HE ENOUGH TO DEVELOP A RELATIONSHIP BETWEEN THE TWO. THE MAJORITY OF THE CHOLESTEROL IN THE SERUM IS FOUND IN THE LDL.

GRAPH 6 APO A-1 VS. TOTAL CHOLESTEROL/HDL CHOL RATIO THIS GRAPH SHOWS ENOUGH CORRELATION FOR A POSSIBLE RELATIONSHIP BETWEEN APO A-1 AND THE TC/HDL CHOL RATIO. THE PREVIOUS GRAPH REVEALS A LACK OF CORRELATION AMONG APO A-1 AND TC, SO THE WELL CORRELATED RELATIONSHIP BETWEEN HDL CHOL AND APO A-1 CAN BE MARKED AS A FACTOR IN CREATING A POSSIBLE RELATIONSHIP BETWEEN THESE TWO FACTORS. ALTHOUGH THE APO A-1 VALUES ARE NOT CONSIDERED TO BE AS ACCURATE OF INDICATORS OF CAD AS THE A-1/B RATIO, THE RELATIONSHIP SHOWN HERE IS THAT AS A PERSON'S APO A-1 VALUE GETS HIGHER, THEIR TC/HDL CHOL RATIO GENERALLY GETS LOWER. THIS HYPOTHESIS CORRELATES

WELL WITH INFORMATION THAT STATES THAT A HIGHER APO A-1 LEVEL IS AN INDICATOR OF A LESSER RISK FOR CAD

GRAPH 7 APO A-1 VS. RISK INDEX NO RELATIONSHIP CAN BE SEEN BETWEEN APO A-1 AND THE RISK INDEX ON THIS GRAPH. THIS IS EASILY UNDERSTOOD BECAUSE APO A-1 HAS NOTHING TO DO WITH DETERMINING THE RISK INDEX. THE CLOSEST RELATIONSHIP APO A-1 HAS TO THE RISK INDEX IS THROUGH HDL, WHICH IS ONLY A SMALL FACTOR IN CALCULATING THE RISK INDEX.

GRAPH 8 APO A-1 VS. A-1/B RATIO THERE IS SOME CORRELATION BETWEEN APO A-1 AND THE A-1/B RATIO. THIS OCCURS BECAUSE A HIGH APO A-1 VALUE TENDS TO LEND ITSELF TO A HIGHER A-1/B RATIO. HOWEVER, THE APO B VALUE IS AN IMPORTANT FACTOR AND A TIGHT RELATIONSHIP AMONG APO A-1 AND THE A-1/B RATIO DOES NOT EXIST. A GOOD CORRELATION IS THEREFORE NOT FOUND, PRIMARILY BECAUSE THE RATIO DEPENDS ON THE APO B VALUE.

GRAPH 9 APO B VS. LDL CHOL MUCH LIKE THE RELATIONSHIP BETWEEN APO A-1 AND HDL CHOL, THE APO B VS. LDL CHOL GRAPH HAS GOOD CORRELATION. THIS IS EXPECTED BECAUSE APO B IS THE PREDOMINANT APOLIPOPROTEIN IN LDL. SO A HIGH APO B VALUE SHOULD PRODUCE A HIGH LDL CHOL VALUE. AS THIS GRAPH SHOWS, AN INCREASE IN LDL CHOL IS PROPORTIONAL TO THE INCREASE IN APO B AND AN OVERALL INCREASE IN LDL CONCENTRATION.

GRAPH 10 APO B VS. TRIG THIS GRAPH COMPARES WELL TO THE APO A-1 VS. TRIG GRAPH. THE TRIG VALUES ARE CONCENTRATED BETWEEN 50 AND 200 ON THE GRAPH, BUT THE LARGE SPREAD OF APO B VALUES REVEALS A LACK OF CORRELATION. THIS IS EXPECTED BECAUSE THE MAJORITY OF TRIGS ARE FOUND IN THE VLDL, WHILE THE HIGHEST PERCENTAGE BY PARTICLE MASS OF APO B IS LOCATED IN THE LDL.

GRAPH 11 APO B VS. HDL CHOL THERE IS NO CORRELATION AMONG APO B AND HDL CHOL, AS SHOWN BY THIS GRAPH. APO B IS THE PREDOMINANT APOLIPOPROTEIN IN LDL, WHILE HDL IS COMPOSED MOSTLY OF APO A-1.

GRAPH 12 APO B VS. TC THERE IS A GOOD CORRELATION AMONG APO B AND TOTAL CHOLESTEROL. THIS CAN BE ATTRIBUTED TO THE APO B'S JOB AS A CARRIER OF CHOLESTEROL IN LDL. BECAUSE LDL CONTAINS THE MOST CHOLESTEROL BY PERCENTAGE OF PARTICLE MASS AND IS A LARGE COMPONENT OF TC, A RELATIONSHIP BETWEEN APO B AND TOTAL CHOLESTEROL IS EXPECTED.

GRAPH 13 APO B VS. TC/HDL CHOL RATIO THE RELATIONSHIP BETWEEN APO B AND THE TC/HDL CHOL RATIO IS SIMILAR TO THE APO A-1 VS. THE TC/HDL CHOL RATIO RELATIONSHIP. ALTHOUGH APO A-1 DOES NOT CORRELATE AS WELL WITH TC AS APO B DOES, THEY BOTH HAVE A GENERAL RELATIONSHIP WITH THE TC/HDL CHOL RATIO. WITH APO B, THE GRAPH SHOWS THAT AN INCREASE IN APO B GENERALLY LEADS TO A HIGHER TC/HDL CHOL RATIO. THIS CAN

BE PREDICTED BECAUSE APO B IS A CHOLESTEROL CARRIER. THE GRAPH OF THE A-1/B RATIO VS. THE TC/HDL CHOL RATIO SHOULD SHOW A BETTER CORRELATION THAN THE APO A-1 AND APO B VS. TC/HDL CHOL RATIO DO SEPARATELY.

GRAPH 14 APO B VS. RISK INDEX SURPRISINGLY ENOUGH, APO B CORRELATES MUCH BETTER AGAINST THE RISK INDEX THAN APO A-1 DOES. ALTHOUGH THE RELATIONSHIP IS NOT REAL NARROW OR DEFINED, A GENERALIZED RELATIONSHIP IS VISIBLE. THIS COULD BE ATTRIBUTED TO THE FACT THAT AS AN INCREASE IN APO B OCCURS, AN INCREASE IN LDL CHOL IS INEVITABLE, WHICH INCREASES THE TOTAL CHOLESTEROL WHICH COULD, IN TURN, INCREASE THE RISK INDEX. ALTHOUGH SEVERAL OTHER FACTORS ARE INVOLVED WHICH COULD ALTER THIS HYPOTHESIS, A GENERAL CORRELATION CAN BE DRAWN FROM THIS GRAPH. IT IS PROBABLY SAFE TO SAY THAT IF A HIGH APO B VALUE IS PRESENT, THERE IS A GOOD CHANCE THAT THE PATIENT'S OTHER VALUES ARE NOT GOOD EITHER, PRODUCING A HIGH RISK INDEX.

GRAPH 15 APO B VS. A-1/B RATIO A MORE DISTINCT CORRELATION CAN BE FOUND AMONG APO B AND THE A-1/B RATIO THAN IN THE APO A-1 AND A-1/B RATIO GRAPH. AS THE DENOMINATOR, APO B WEIGHS MORE HEAVILY IN DETERMINING THE RATIO. FOR THIS REASON, APO B IS BETTER RELATED TO THE A-1/B RATIO THAN APO A-1 AND CORRELATES NICELY.

GRAPH 16 LDL CHOL VS. TRIG THERE IS A VERY POOR CORRELATION AMONG LDL CHOL AND TRIG. THIS IS PROBABLY BECAUSE THE MAJORITY OF THE TRIGLYCERIDE IN THE SERUM IS IN VLDL, WHILE LDL HAS VERY LITTLE TRIGLYCERIDE. WITH SO MUCH TRIG OUTSIDE OF THE LDL, IT IS DIFFICULT TO DEVELOP ANY RELATIONSHIP AMONG THE TWO.

GRAPH 17 LDL CHOL VS. HDL CHOL THIS GRAPH SHOWS THAT THERE IS ABSOLUTELY NO CORRELATION BETWEEN LDL CHOL AND HDL CHOL. THIS IS EXPECTED BECAUSE THE AMOUNT OF CHOL IN HDL AND LDL IS NOT DEPENDENT ON THE OTHER LIPOPROTEIN. RATHER, THE PROTEIN TRANSFER PROCESS AND OTHER FACTORS DETERMINE THE CHOLESTEROL CONTENT OF THE LIPOPROTEINS. THE REASON FOR THIS LACK OF CORRELATION CAN BE BLAMED ON THE FACT THAT EVERY INDIVIDUAL HAS DIFFERENT CONCENTRATIONS OF LDL AND HDL CHOLESTEROL, THEREFORE MAKING A LDL CHOL AND HDL CHOL COMPARISON IMPOSSIBLE.

GRAPH 18 LDL CHOL VS. TOTAL CHOLESTEROL A VERY WELL DEFINED RELATIONSHIP IS VISIBLE BY THE EXCELLENT CORRELATION OF LDL CHOL WITH TC. THIS IS EXPECTED BECAUSE LDL CHOL MAKES UP THE MAJORITY OF THE TC.

GRAPH 19 LDL CHOL VS. TC/HDL CHOL RATIO ALTHOUGH PREVIOUS GRAPHS SHOWED A LACK OF CORRELATION AMONG LDL CHOL AND HDL CHOL, THE GOOD CORRELATION AMONG LDL CHOL AND TC IS ONE REASON WHY THERE IS A LOOSE CORRELATION AMONG LDL CHOL AND

THE TC/HDL CHOL RATIO. THE FACT THAT THE TC/HDL CHOL RATIO IS USED AS A PREDICTOR OF CAD RISK IS ANOTHER REASON WHY THEY RELATE. LDL CHOL IS ALSO USED TO DETERMINE RISK. THE HIGHER THE LDL CHOL LEVEL, THE GREATER THE RISK. THE GREATER THE CHOLESTEROL RATIO, THE GREATER THE RISK ALSO, WHICH PRODUCES THE RELATIONSHIP SHOWN BY THIS GRAPH.

GRAPH 20 LDL CHOL VS. RISK INDEX MUCH LIKE THE PREVIOUS GRAPH, LDL CHOL VS. RISK INDEX MIGHT BE ASSUMED TO HAVE A DEFINITE, YET LOOSE, CORRELATION WITH THE RISK INDEX BECAUSE THE RISK INDEX, LIKE THE TC/HDL CHOL RATIO, IS A METHOD BY WHICH TO PREDICT CAD RISK. HOWEVER, LDL CHOL DOES NOT SHOW A DEFINITE RELATIONSHIP WITH THE RISK INDEX IN THIS GRAPH. THE REASON FOR THIS DEVIATION COULD BE THE GREATER NUMBER OF VARIABLES IN THE RISK INDEX IN COMPARISON TO THE TC/HDL CHOL RATIO.

GRAPH 21 LDL CHOL VS. A-1/B RATIO LDL CHOL IS INVERSELY PROPORTIONAL TO THE A-1/B RATIO. THERE IS NOT A VERY RIGID OR DISTINCT CORRELATION, BUT A GENERAL RELATIONSHIP CAN BE EXPECTED AND IS SHOWN IN THE GRAPH OF THE TWO. AN INCREASE IN LDL IS ASSOCIATED WITH HIGHER RISK, AS IS A LOW A-1/B RATIO. SO AS THE LDL CHOL DECREASES, THE A-1/B RATIO INCREASES, PRODUCING A RELATIONSHIP WITH A LOOSE CORRELATION.

GRAPH 22 TRIG VS. HDL CHOL ALTHOUGH THERE APPEARS TO PERHAPS BE A LOOSE CORRELATION AMONG TRIG AND HDL CHOL, A RELATIONSHIP BETWEEN THE TWO DOES NOT SEEM REALISTIC. TRIG IS FOUND PREDOMINANTLY IN VLDL AND ONLY IN VERY SMALL AMOUNTS IN HDL.

GRAPH 23 TRIG VS. TC A RELATIONSHIP BETWEEN THESE TWO VARIABLES IS NOT SHOWN BY THIS GRAPH. THIS IS EXPECTED, HOWEVER, BECAUSE TRIGS ARE NOT PART OF THE TOTAL CHOLESTEROL COUNT. TRIGS ARE STORED FOR ENERGY, AND THE TWO VARIABLES ARE TWO SEPARATE ENTITIES.

GRAPH 24 TRIG VS. TC/HDL CHOL RATIO THIS IS THE BEST CORRELATION TRIG HAS HAD WHEN COMPARED TO ANY OF THE PREVIOUS GRAPHS. THERE IS A SURPRISINGLY GOOD RELATIONSHIP AMONG TRIG AND THE TC/HDL CHOL RATIO. THIS GRAPH SHOWS, LIKE SOME OF THE PREVIOUS GRAPHS, THAT THE TWO VARIABLES MIGHT NOT REALLY BE RELATED IN A WAY THAT IS CLEAR AND DEFINITE, BUT WHEN THEY ARE USED IN CONJUNCTION WITH EACH OTHER, THE COMBINATION OF THE TWO PROVIDES A VALUABLE TOOL FOR PREDICTING CAD.

GRAPH 25 TRIG VS. RISK INDEX THIS GRAPH SHOWS THAT THERE IS A POSSIBLE RELATIONSHIP AMONG THESE TWO VARIABLES. THE LACK OF DEFINITE CORRELATION CAN BE RELATED TO THE FACT THAT TRIG PLAYS NO PART IN THE CALCULATION OF THE RISK INDEX. THE USE OF AGE IN THE RISK INDEX CAUSES THERE TO BE LESS

CORRELATION AMONG TRIG AND THE RISK INDEX AS THERE WAS BETWEEN TRIG AND THE TC/HDL CHOL RATIO. IN GENERAL, AN INCREASE IN TRIG VALUES CORRESPONDS WITH A HIGHER RISK INDEX.

GRAPH 26 TRIG VS. A-1/B RATIO THERE IS LITTLE, IF ANY, CORRELATION AMONG TRIG AND THE A-1/B RATIO. THIS CAN BE ATTRIBUTED TO THE FACT THAT ALL PEOPLE ARE DIFFERENT AND HAVE DIFFERENT EATING HABITS, THUS HAVING DIFFERENT TRIG VALUES. THERE ARE MANY PATIENTS THAT HAVE THE SAME A-1/B RATIO, BUT THE GRAPH SHOWS HOW DRAMATICALLY THEIR TRIG VALUES DIFFER. FOR THIS REASON, THERE IS NOT A RELATIONSHIP AMONG TRIG AND THE A-1/B RATIO.

GRAPH 27 HDL CHOL VS. TC SURPRISINGLY ENOUGH, THERE IS NO RELATIONSHIP BETWEEN THESE TWO CHOLESTEROL MEASUREMENTS, EVEN THOUGH HDL CHOL IS PART OF THE TOTAL CHOLESTEROL. THIS CAN BE ATTRIBUTED TO THE FACT THAT THE MAJORITY OF THE CHOLESTEROL IN THE BODY IS IN THE LDL, AND THE HDL DOES NOT WEIGH HEAVILY IN DETERMINING TC BECAUSE OF ITS SMALL PERCENTAGE OF CHOLESTEROL.

GRAPH 28 HDL CHOL VS. TC/HDL CHOL RATIO IN COMPARISON TO THE HDL CHOL VS. TC GRAPH, THIS GRAPH IS VERY WELL CORRELATED. THIS OCCURS BECAUSE HDL CHOL IS IN THE DENOMINATOR OF THE TC/HDL CHOL RATIO, AND THUS LOWERS THE AMOUNT OF DIFFERENCE BETWEEN HDL CHOL AND THE TC VALUES.

HOWEVER, THERE IS ALSO A RELATIONSHIP BETWEEN THE TWO VALUES. THIS GRAPH SHOWS THAT THE HIGHER THE HDL CHOL LEVEL, THE LOWER THE TC/HDL CHOL RATIO IS.

GRAPH 29 HDL CHOL VS. RISK INDEX THERE IS A VERY WEAK CORRELATION AMONG THE HDL CHOL AND THE RISK INDEX. THERE IS A WIDE SCATTER OF POINTS ON BOTH SIDES OF THE LINEAR REGRESSION LINE, BUT A GENERAL RELATIONSHIP EXISTS. AS HDL CHOL VALUES DECREASE, THE RISK INDEX INCREASES.

GRAPH 30 HDL CHOL VS. A-1/B RATIO THIS GRAPH SHOWS A GENERAL INCREASE IN HDL CHOL VALUES AS THE A-1/B RATIO INCREASES. HOWEVER, THE VARIANCE OF THE HDL CHOL LEVELS FOR PATIENTS WITH THE SAME A-1/B RATIOS SHOWS THAT THIS CORRELATION IS NOT A STRONG ONE.

GRAPH 31 TC VS. TC/HDL CHOL RATIO ALTHOUGH ONE WOULD ASSUME THAT THERE IS A DEFINITE RELATIONSHIP AMONG TC AND THE TC/HDL CHOL RATIO, THERE IS NOT THAT GOOD OF A CORRELATION BETWEEN THE TWO. IT CAN BE GENERALLY STATED THAT THE HIGHER THE TC IS, THE GREATER THE TC/HDL CHOL RATIO WILL BE. BECAUSE THE TC/HDL CHOL RATIO HAS THE HDL CHOL IN THE DENOMINATOR, THE VARIETY OF HDL CHOL VALUES CAUSES A COMPARISON TO TC TO NOT BE AS WELL CORRELATED AS ONE WOULD EXPECT.

GRAPH 32 TC VS. RISK INDEX NO REAL RELATIONSHIP IS APPARENT AMONG TC AND THE RISK INDEX, AS SHOWN BY THE GRAPH. THE RISK INDEX IS COMPOSED OF SEVERAL FACTORS ALONG WITH THE TC, MAKING A LESSER CHANCE FOR CORRELATION.

GRAPH 33 TC VS. A-1/B RATIO THERE IS A SLIGHT CORRELATION BETWEEN TC AND THE A-1/B RATIO. SEVERAL PATIENTS HAVE THE SAME A-1/B RATIOS, BUT THE TC VALUES TAKE UP A WIDE RANGE EVEN THOUGH THE A-1/B RATIOS ARE THE SAME. FOR THIS REASON, THE A-1/B RATIO IS CONSIDERED A BETTER PREDICTOR OF CAD.

GRAPH 34 TC/HDL CHOL RATIO VS. RISK INDEX A GOOD CORRELATION IS PRESENT AMONG THESE TWO VARIABLES. THE REASON FOR THIS GOOD CORRELATION IS THAT BOTH ARE USED TO PREDICT THE RISK OF DEVELOPING CAD. ALSO, THE TC/HDL CHOL RATIO IS USED IN DETERMINING THE RISK INDEX.

GRAPH 35 TC/HDL CHOL RATIO VS. A-1/B RATIO THERE IS A GOOD CORRELATION BETWEEN THESE TWO RATIOS. ALTHOUGH THEY DO NOT EXACTLY REPRODUCE EACH OTHER, THE ARE BOTH EXCELLENT PREDICTORS OF CAD IN THEIR OWN RIGHT. HOWEVER, THE APOLIPOPROTEIN RATIO SEEMS TO BE THE MORE ACCURATE OF THE TWO RATIOS, AS ITS SCALE IS MUCH SMALLER AND PROVIDES A MORE CLEAR CUT DEFINITION OF WHAT A PERSON'S RISK IS.

GRAPH 36 RISK INDEX VS. A-1/B RATIO THERE IS NOT A GOOD CORRELATION AMONG THESE TWO GROUPS OF VALUES. ONCE AGAIN,

THERE IS A GREAT SPREAD OF RISK INDEX VALUES WHERE THE A-1/B RATIOS ARE OF THE SAME VALUE. THIS LACK OF GOOD CORRELATION IS PARTLY BECAUSE OF THE USE OF AGE IN THE RISK INDEX, AND THE FACT THAT THE SCALE IS SO LARGE THAT IT REDUCES THE ACCURACY. THE A-1/B RATIO IS A MUCH MORE ACCURATE AND SCALED MEASUREMENT, AND PROVIDES, IN MY OPINION, THE BEST METHOD FOR PREDICTING THE RISK OF CAD AVAILABLE.

GRAPH RESULTS DETERMINED BY CORRELATION COEFFICENT

NO CORRELATION
R LESS THAN .5

APO A-1 VS. APO B
APO A-1 VS. LDL CHOL
APO A-1 VS. TRIG
APO A-1 VS. TC
APO A-1 VS. RISK INDEX
APO B VS. TRIG
APO B VS. HDL CHOL
LDL CHOL VS. TRIG
LDL CHOL VS. HDL CHOL
LDL CHOL VS. RISK INDEX
TRIG VS. TC
TRIG VS. A-1/B RATIO
HDL CHOL VS. TC
TC VS. RISK INDEX

POSSIBLE CORRELATION
R BETWEEN .5 AND .75

APO A-1 VS. TC/HDL CHOL RATIO
APO A-1 VS. A-1/B RATIO
APO B VS. TC/HDL CHOL RATIO
APO B VS. RISK INDEX
LDL CHOL VS. TC/HDL CHOL RATIO
LDL CHOL VS. A-1/B RATIO
TRIG VS. HDL CHOL
TRIG VS. TC/HDL CHOL RATIO
TRIG VS. RISK INDEX
HDL CHOL VS. RISK INDEX
HDL CHOL VS. A-1/B RATIO
TC VS. TC/HDL CHOL RATIO
TC VS. A-1/B RATIO
TC/HDL CHOL RATIO VS. RISK INDEX
RISK INDEX VS. A-1/B RATIO

GOOD CORRELATION
R GREATER THAN .75

APO A-1 VS. HDL CHOL
APO B VS. LDL CHOL
APO B VS. TC
APO B VS. A-1/B RATIO
LDL CHOL VS. TC
HDL CHOL VS. TC/HDL CHOL RATIO
TC/HDL CHOL RATIO VS. A-1/B RATIO

PRINTOUT EXPLANATIONS

THE FOLLOWING PAGES ARE COPIES OF THE PRINTOUTS RECEIVED FROM THE BECKMAN ARRAY AT WILFORD HALL MEDICAL CENTER AT LACKLAND AIR FORCE BASE THAT CONTAIN THE APO A-1 AND THE APO B VALUES AS DETERMINED BY NEPHELOMETRIC METHOD. A-1/B RATIOS HAVE BEEN CALCULATED FOR THE JULY 11 AND 12 TEST RUNS. THE MAY 17 AND 30 HAVE CHARTS PRECEDING THE BECKMAN PRINTOUTS THAT CONTAIN THE A-1/B RATIOS AND OTHER INFORMATION THAT CAN BE FOUND ON THE CHART FOUND IN THE CAD PREDICTION STUDY SECTION OF THIS REPORT.

PATIENT	CASE #	A1/B RATIO	CHOL	HDL	C/H RATIO	TRIG	RISK
	M24207	125/96=1.3	200	34	5.9	151	15311
	D24211	157/70=2.2	179	50	3.6	72	4128
	D24210	137/110=1.2	239	40	6.0	68	10125
	C24215	136/102=1.3	224	38	5.9	82	7832
	D24217	145/92=1.6	186	39	4.8	73	6649
	D24216	133/95=1.4	188	34	5.5	164	7990
	D24221	137/71=1.9	182	45	4.0	66	3315
	C24220	129/110=1.2	219	31	7.1	173	11279
	D24183	192/60=3.2	179	67	2.7	51	3385
	M24218	142/88=1.6	201	46	4.4	125	10567
	C24219	140/40=3.5	121	36	3.4	127	4165
	C24222	125/112=1.1	242	37	6.5	235	8001
	D24223	174/61=2.9	177	70	2.5	35	3234
	C24224	125/98=1.3	207	35	5.9	89	2379
	C24225	145/59=2.5	149	46	3.2	80	3233
	D24226	154/63=2.4	166	47	3.5	76	4902
	D24227	151/97=1.6	231	46	5.0	96	11727
	C24228	159/90=1.8	203	49	4.1	78	7546
	C24229	125/78=1.6	183	26	7.0	310	5803

RESULTS DONE AT WHMC ON 17 MAY 90 BY TSGT ANDERSON & SSGT MOORE

LEFT OPTICS

Thursday, May 17
13:47

FILTERED SCATTER READING

GAIN: 1	121
GAIN: 2	120
GAIN: 3	120
GAIN: 4	OVER
ADJUST %	1.5

RIGHT OPTICS

Thursday, May 17
13:49

FILTERED SCATTER READING

GAIN: 1	120
GAIN: 2	120
GAIN: 3	120
GAIN: 4	OVER
ADJUST %	0.0

Thursday, May 17
14:15

LACKLAND A.F.B.

1 M902179

L APA	87.0	MG/DL	1:36
L APA	76.8	MG/DL	1:36
L APA	77.5	MG/DL	1:36
LEFT:	APA CALIBRATED TO 96.8		MG/DL
R APA	65.9	MG/DL	1:36
R APA	60.8	MG/DL	1:36
R APA	60.9	MG/DL	1:36
RIGHT:	APA CALIBRATED TO 96.8		MG/DL

2 M902179

L APB	106	MG/DL	1:36
L APB	105	MG/DL	1:36
LEFT:	APB CALIBRATED TO 108		MG/DL
R APB	85.2	MG/DL	1:36
R APB	86.7	MG/DL	1:36
RIGHT:	APB CALIBRATED TO 108		MG/DL

LACKLAND A.F.B.

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS	
3	APA M907094				SERUM		
	L APA	97.7	MG/DL	1:36		79.00	113.0
	R APA	94.7	MG/DL	1:36		79.00	113.0
4	APB M907094				SERUM		
	L APB	117	MG/DL	1:36		100.0	130.0
	R APB	114	MG/DL	1:36		100.0	130.0

LACKLAND A.F.B.

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS
5	207				SERUM	
	L APA	125	MG/DL	1:36		
	R APB	96.3	MG/DL	1:36		
6	211				SERUM	
	L APA	157	MG/DL	1:36		
	R APB	70.3	MG/DL	1:36		
7	210				SERUM	
	L APA	137	MG/DL	1:36		
	R APB	110	MG/DL	1:36		
8	215				SERUM	
	L APA	136	MG/DL	1:36		
	R APB	102	MG/DL	1:36		
9	217				SERUM	
	L APA	145	MG/DL	1:36		
	R APB	92.4	MG/DL	1:36		
10	216				SERUM	
	L APA	133	MG/DL	1:36		
	R APB	94.7	MG/DL	1:36		
11	221				SERUM	
	L APA	137	MG/DL	1:36		
	R APB	71.0	MG/DL	1:36		
12	220				SERUM	
	L APA	129	MG/DL	1:36		
	R APB	110	MG/DL	1:36		

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS
13	183				SERUM	
	L APA	192	MG/DL	1:36		
	R APB	59.9	MG/DL	1:36		
14	218				SERUM	
	L APA	142	MG/DL	1:36		
	R APB	88.0	MG/DL	1:36		
15	219				SERUM	
	L APA	140	MG/DL	1:36		
	R APB	40.1	MG/DL	1:36		
16	222				SERUM	
	L APA	125	MG/DL	1:36		
	R APB	112	MG/DL	1:36		
17	223				SERUM	
	L APA	174	MG/DL	1:36		
	R APB	61.0	MG/DL	1:36		
18	224				SERUM	
	L APA	125	MG/DL	1:36		
	R APB	97.6	MG/DL	1:36		
19	225				SERUM	
	L APA	145	MG/DL	1:36		
	R APB	58.7	MG/DL	1:36		
20	226				SERUM	
	L APA	154	MG/DL	1:36		
	R APB	63.4	MG/DL	1:36		
21	227				SERUM	
	L APA	151	MG/DL	1:36		
	R APB	96.7	MG/DL	1:36		
22	228				SERUM	

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS	
L	APA	159	MG/DL	1:36			
R	APB	89.7	MG/DL	1:36			
23	229				SERUM		
L	APA	125	MG/DL	1:36			
R	APB	78.0	MG/DL	1:36			
24	APA M907094				SERUM		
L	APA	97.0	MG/DL	1:36		79.00	113.0
R	APA	96.3	MG/DL	1:36		79.00	113.0
25	APB M907094				SERUM		
L	APB	116	MG/DL	1:36		100.0	130.0
R	APB	115	MG/DL	1:36		100.0	130.0

PATIENT	CASE#	A1/B ratio	CHOL	HDL	C/H RATIO	RISK INDEX
	C24236	1.3	187	30	6.2	14,700
	M24234	1.9	197	52	3.8	9,060
	D24232	1.5				
	C24231	2.2	141	43	3.3	2,482
	M24233	2.6	120	39	3.1	6,748
	C24241	1.7	162	35	4.6	2,090
	M24238	2.7	218	★ 84	★ 2.6	5,003
	D24243	2.3	161	48	3.4	3,051
	D24242	1.9	165	47	3.5	4,220
	C24244	1.2	240	43	5.6	5,612
	C24240	1.5	225	42	5.3	6,971
	D24248	1.5	192	34	5.6	7,435
	D24249	2.7	200	66	3.0	4,111
	C24250	1.4	191	38	5.0	4,385
	C24251	1.4	211	45	4.7	2,494
	C24247	1.2	227	39	5.8	13,541
	D24253	1.3	225	34	6.6	12,409
	D24252	★ 1.0	210	34	6.2	15,095
	D24255	1.7	218	58	3.8	6,094
	C24254	1.1	315	57	5.5	9,578
	C24257	1.9	160	51	3.1	6,944
	C24258	★ 1.0	235	38	6.2	14,018
	C24259	1.8	196	54	3.6	8,846
	D24260	2.2	163	51	3.2	1,373
	C24256	★ 0.9	258	41	6.3	3,308
	M24262	1.6	165	28	5.9	15,897
	M24264	★ 1.0	221	32	6.9	19,189
	M24265	1.2	195	32	6.1	15,974
	C24263	1.8	164	45	3.6	9,205
	D24246	1.5	156	32	4.9	7,502
	C24266	1.1	248	38	6.5	8,402
	D24267	1.8	199	54	3.7	4,514
	C24268	★ 0.8	259	35	7.4	16,646
	D24269	1.4	225	62	3.6	5,090
	D24270	1.5	193	46	4.2	5,909

RESULTS PERFORMED AT WHMC ON [redacted]90 BY AIC YZAGUIRRE

APA - 96-176 mg/dL

APB - 43-128 mg/dL

Wednesday, May 30
14:25

LACKLAND A.F.B.

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS	
1	APA M907094				SERUM		
	L APA	97.0	MG/DL	1:36		79.00	113.0
	R APA	96.8	MG/DL	1:36		79.00	113.0
	L APB			1:36		Unstable reaction	
	L APB	40.6	MG/DL	1:36			
	R APB	41.1	MG/DL	1:36			
2	APB M907094				SERUM		
	L APA	> 225	MG/DL	1:36	ORHI		
	L APA	283	MG/DL	1:72			
	R APA	> 225	MG/DL	1:36	ORHI		
	R APA	317	MG/DL	1:72			
	L APB	116	MG/DL	1:36		100.0	130.0
	R APB	118	MG/DL	1:36		100.0	130.0
3	C24236				SERUM		
	R APA	130	MG/DL	1:36			
	L APB	104	MG/DL	1:36			
4	M24234				SERUM		
	R APA	159	MG/DL	1:36			
	L APB	82.9	MG/DL	1:36			
5	D24232				SERUM		
	R APA	117	MG/DL	1:36			
	L APB	80.1	MG/DL	1:36			
6	C24231				SERUM		
	R APA	130	MG/DL	1:36			
	L APB	59.2	MG/DL	1:36			
7	M24233				SERUM		

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS
	R APA	136	MG/DL	1:36		
	L APB	53.1	MG/DL	1:36		
8	C24241				SERUM	
	R APA	122	MG/DL	1:36		
	L APB	72.8	MG/DL	1:36		
9	M24238				SERUM	
	R APA	> 225	MG/DL	1:36	ORHI	
	R APA	224	MG/DL	1:72		
	L APB	84.4	MG/DL	1:36		
10	D24243				SERUM	
	L APA	149	MG/DL	1:36		
	R APB	65.9	MG/DL	1:36		
11	D24242				SERUM	
	L APA	138	MG/DL	1:36		
	R APB	70.9	MG/DL	1:36		
12	C24244				SERUM	
	L APA	141	MG/DL	1:36		
	R APB	118	MG/DL	1:36		
13	C24240				SERUM	
	L APA	155	MG/DL	1:36		
	R APB	105	MG/DL	1:36		
14	D24248				SERUM	
	L APA	128	MG/DL	1:36		
	R APB	85.6	MG/DL	1:36		
15	D24249				SERUM	
	L APA	199	MG/DL	1:36		
	R APB	73.1	MG/DL	1:36		
16	C24250				SERUM	
	L APA	130	MG/DL	1:36		
	R APB	92.3	MG/DL	1:36		

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS
17	C24251				SERUM	
	L APA	141	MG/DL	1:36		
	R APB	101	MG/DL	1:36		
18	C24247				SERUM	
	L APA	133	MG/DL	1:36		
	R APB	107	MG/DL	1:36		
19	D24253				SERUM	
	L APA	135	MG/DL	1:36		
	R APB	107	MG/DL	1:36		
20	D24252				SERUM	
	L APA	107	MG/DL	1:36		
	R APB	106	MG/DL	1:36		
21	D24255				SERUM	
	L APA	170	MG/DL	1:36		
	R APB	102	MG/DL	1:36		
22	C24254				SERUM	
	L APA	166	MG/DL	1:36		
	R APB	152	MG/DL	1:36		
23	C24257				SERUM	
	L APA	136	MG/DL	1:36		
	R APB	69.8	MG/DL	1:36		
24	C24258				SERUM	
	L APA	131	MG/DL	1:36		
	R APB	130	MG/DL	1:36		
25	C24259				SERUM	
	L APA	164	MG/DL	1:36		
	R APB	89.9	MG/DL	1:36		
26	D24260				SERUM	

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS
	L APA	153	MG/DL	1:36		
	R APB	69.6	MG/DL	1:36		
27	C24256				SERUM	
	L APA	118	MG/DL	1:36		
	R APB	129	MG/DL	1:36		
28	M24262				SERUM	
	L APA	135	MG/DL	1:36		
	R APB	82.4	MG/DL	1:36		
29	M24264				SERUM	
	L APA	116	MG/DL	1:36		
	R APB	117	MG/DL	1:36		
30	M24265				SERUM	
	L APA	131	MG/DL	1:36		
	R APB	109	MG/DL	1:36		
31	C24263				SERUM	
	L APA	126	MG/DL	1:36		
	R APB	69.4	MG/DL	1:36		
32	D24246				SERUM	
	L APA	106	MG/DL	1:36		
	R APB	72.2	MG/DL	1:36		
33	C24266				SERUM	
	L APA	131	MG/DL	1:36		
	R APB	120	MG/DL	1:36		
34	D24267				SERUM	
	L APA	151	MG/DL	1:36		
	R APB	84.4	MG/DL	1:36		
35	C24268				SERUM	
	L APA	126	MG/DL	1:36		
	R APB	159	MG/DL	1:36		

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS	
36	D24269				SERUM		
	L APA	148	MG/DL	1:36			
	R APB	103	MG/DL	1:36			
37	D24270				SERUM		
	L APA	139	MG/DL	1:36			
	R APB	90.0	MG/DL	1:36			
38	APA M907094				SERUM		
	L APA	93.6	MG/DL	1:36		79.00	113.0
	R APA	97.9	MG/DL	1:36		79.00	113.0
	L APB			1:36		Unstable reaction	
	L APB	40.6	MG/DL	1:36			
	R APB	40.7	MG/DL	1:36			
39	APB M907094				SERUM		
	L APA >	225	MG/DL	1:36	ORHI		
	L APA	304	MG/DL	1:72			
	R APA >	225	MG/DL	1:36	ORHI		
	R APA	319	MG/DL	1:72			
	L APB	116	MG/DL	1:36		100.0	130.0
	R APB	119	MG/DL	1:36		100.0	130.0

LACKLAND A.F.B.

	CHEM	RESULT	UNITS	DILUTION		AGXS	RANGE/FLAGS	
1	APA M907094					SERUM		
	L APA	95.2	MG/DL	1:36			79.00	113.0
	R APA	94.6	MG/DL	1:36			79.00	113.0
2	APB M907094					SERUM		
	L APB	116	MG/DL	1:36			100.0	130.0
	R APB	121	MG/DL	1:36			100.0	130.0
3		271				SERUM		
	L APA	139	MG/DL	1:36	1.2			
	R APB	76.9	MG/DL	1:36				
4		274				SERUM		
	L APA	138	MG/DL	1:36				
	R APB	79.8	MG/DL	1:36	1.7			
5		273				SERUM		
	L APA	129	MG/DL	1:36				
	R APB	95.6	MG/DL	1:36	1.3			
6		278				SERUM		
	L APA	139	MG/DL	1:36				
	R APB	80.6	MG/DL	1:36	1.7			
7		276				SERUM		
	L APA	106	MG/DL	1:36				
	R APB	84.3	MG/DL	1:36	1.3			
8		281				SERUM		
	L APA	123	MG/DL	1:36				
	R APB	82.7	MG/DL	1:36	1.5			

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS
9		279			SERUM	
	L APA	122	MG/DL	1:36	1.2	
	R APB	98.2	MG/DL	1:36		
10		277			SERUM	
	L APA	96.2	MG/DL	1:36	1.0	
	R APB	96.6	MG/DL	1:36		
11		261			SERUM	
	L APA	131	MG/DL	1:36	1.5	
	R APB	84.5	MG/DL	1:36		
12		275			SERUM	
	L APA	167	MG/DL	1:36	2.6	
	R APB	63.6	MG/DL	1:36		
13		283			SERUM	
	L APA	140	MG/DL	1:36	1.3	
	R APB	108	MG/DL	1:36		
14		285			SERUM	
	L APA	150	MG/DL	1:36	2.1	
	R APB	70.4	MG/DL	1:36		
15		286			SERUM	
	L APA	163	MG/DL	1:36	1.9	
	R APB	88.0	MG/DL	1:36		
16		287			SERUM	
	L APA	99.2	MG/DL	1:36	1.0	
	R APB	103	MG/DL	1:36		
17		291			SERUM	
	L APA	96.9	MG/DL	1:36	1.1	
	R APB	88.7	MG/DL	1:36		

18 293 Wednesday, July 1
15:1

CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS
APO A	171			1.7	
APO B	102				

NOT USED IN STUDY

19 88 SERUM

~~L APA 134 MG/DL 1:36~~
~~R APB 97.8 MG/DL 1:36~~ 1.6

20 289 SERUM

L APA	111	MG/DL	1:36	
R APB	110	MG/DL	1:36	1.0

21 295 SERUM

L APA	89.5	MG/DL	1:36	1.3
R APB	70.5	MG/DL	1:36	

22 297 SERUM

L APA	96.8	MG/DL	1:36	0.8
R APB	125	MG/DL	1:36	

23 298 SERUM

L APA	132	MG/DL	1:36	1.9
R APB	70.9	MG/DL	1:36	

24 300 SERUM

L APA	130	MG/DL	1:36	1.8
R APB	74.1	MG/DL	1:36	

25 302 SERUM

L APA	131	MG/DL	1:36	1.7
R APB	77.9	MG/DL	1:36	

26 294 SERUM

L APA	146	MG/DL	1:36	1.1
R APB	132	MG/DL	1:36	

27 296 SERUM

L APA	102	MG/DL	1:36	0.6
R APB	159	MG/DL	1:36	

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS
28		299			SERUM	
	L APA	143	MG/DL	1:36	2.6	
	R APB	56.1	MG/DL	1:36		
29		301			SERUM	
	L APA	119	MG/DL	1:36	1.0	
	R APB	122	MG/DL	1:36		
30		303			SERUM	
	L APA	99.3	MG/DL	1:36	1.1	
	R APB	90.3	MG/DL	1:36		
31		304			SERUM	
	L APA	112	MG/DL	1:36	1.2	
	R APB	92.1	MG/DL	1:36		
32		305			SERUM	
	L APA	108	MG/DL	1:36	0.9	
	R APB	127	MG/DL	1:36		
33		306			SERUM	
	L APA	108	MG/DL	1:36	1.3	
	R APB	83.5	MG/DL	1:36		
34		307			SERUM	
	L APA	164	MG/DL	1:36	1.6	
	R APB	99.5	MG/DL	1:36		
35		308			SERUM	
	L APA	141	MG/DL	1:36	2.0	
	R APB	68.5	MG/DL	1:36		
36		284			SERUM	
	L APA	143	MG/DL	~~1:36~~		
	R APB	73.5	MG/DL	1:36		
37		314			SERUM	
	L APA	118	MG/DL	1:36		

Wednesday, July 11
15:49

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS
R	APB	69.7	MG/DL	1:36	1.7	
38		315			SERUM	
L	APA	98.6	MG/DL	1:36	1.1	
R	APB	88.5	MG/DL	1:36		
39		311			SERUM	
L	APA	147	MG/DL	1:36	1.9	
R	APB	77.1	MG/DL	1:36		
40		317			SERUM	
L	APA	143	MG/DL	1:36	1.7	
R	APB	83.0	MG/DL	1:36		

Thursday, July 18
15:02

LACKLAND A.F.B.

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS		
1	APA M907094				SERUM			
	L APA	> 225	MG/DL	1:36	ORHI	79.00	113.0	
	L APA	310 ÷ 3	MG/DL	1:72		79.00	113.0	H
	R APA	> 225	MG/DL	1:36	ORHI	79.00	113.0	
	R APA	305 ÷ 3	MG/DL	1:72		79.00	113.0	H
2	APB M907094				SERUM			
	L APB	42.1 x 3	MG/DL	1:36		100.0	130.0	L
	R APB	41.8 x 3	MG/DL	1:36		100.0	130.0	L
3		D24316			SERUM			
	L APA	132	MG/DL	1:36				
	R APB	65.0	MG/DL	1:36	2.0			
4		M24318			SERUM			
	L APA	126	MG/DL	1:36				
	R APB	88.5	MG/DL	1:36	1.4			
5		D24320			SERUM			
	L APA	139	MG/DL	1:36				
	R APB	104	MG/DL	1:36	1.3			
6		C24321			SERUM			
	L APA	125	MG/DL	1:36				
	R APB	102	MG/DL	1:36	1.2			
7		D24322			SERUM			
	L APA	139	MG/DL	1:36				
	R APB	61.9	MG/DL	1:36	2.2			
8		D24323			SERUM			

Thursday, July 12
15:27

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS
	L APA	127	MG/DL	1:36		
	R APB	91.9	MG/DL	1:36	1.4	
9		C24325			SERUM	
	L APA	139	MG/DL	1:36		
	R APB	96.6	MG/DL	1:36	1.4	
10		D24326			SERUM	
	L APA	169	MG/DL	1:36		
	R APB	62.1	MG/DL	1:36	2.7	
11		D24328			SERUM	
	L APA	157	MG/DL	1:36		
	R APB	108	MG/DL	1:36	1.5	
~~12~~	NOT USED IN STUDY	~~K24324~~			SERUM	
	L APA	149	MG/DL	1:36		
	R APB	67.1	MG/DL	1:36		
13		C24330			SERUM	
	L APA	116	MG/DL	1:36		
	R APB	78.6	MG/DL	1:36	1.5	
14		M24313			SERUM	
	L APA	130	MG/DL	1:36		
	R APB	111	MG/DL	1:36	1.2	
15		C24332			SERUM	
	L APA	141	MG/DL	1:36		
	R APB	86.8	MG/DL	1:36	1.6	
16		C24333			SERUM	
	L APA	144	MG/DL	1:36		
	R APB	70.1	MG/DL	1:36	2.1	
17		M24334			SERUM	
	L APA	122	MG/DL	1:36		
	R APB	158	MG/DL	1:36	0.8	

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS
18		D24335			SERUM	
	L APA	129	MG/DL	1:36	1.7	
	R APB	76.8	MG/DL	1:36		
19		C24352			SERUM	
	L APA	112	MG/DL	1:36	1.7	
	R APB	67.2	MG/DL	1:36		
20		M24337			SERUM	
	L APA >	225	MG/DL	1:36	ORHI	
	L APA	218	MG/DL	1:72	2.9	
	R APB	74.2	MG/DL	1:36		
21		D24339			SERUM	
	R APA	126	MG/DL	1:36	1.9	
	L APB	66.8	MG/DL	1:36		
22		C24342			SERUM	
	R APA	102	MG/DL	1:36	1.2	
	L APB	85.3	MG/DL	1:36		
23		C24346			SERUM	
	R APA	129	MG/DL	1:36		
	L APB			1:36	1.9	Unstable reaction
	L APB	137	MG/DL	1:36		
24		D24347			SERUM	
	R APA	137	MG/DL	1:36		
	L APB	86.3	MG/DL	1:36	1.6	
25	NOT USED IN STUDY	~~C24344~~			SERUM	
	R APA	133	MG/DL	1:36		
	L APB	77.2	MG/DL	1:36		
26		D24350			SERUM	
	R APA	139	MG/DL	1:36	1.7	
	L APB	78.4	MG/DL	1:36		
27		D24351			SERUM	

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS
R	APA	124	MG/DL	1:36	1.3	
L	APB	95.4	MG/DL	1:36		
28		D24344			SERUM	
R	APA	151	MG/DL	1:36	2.2	
L	APB	67.7	MG/DL	1:36		
29		C24353			SERUM	
R	APA	136	MG/DL	1:36	2.2	
L	APB	60.5	MG/DL	1:36		
30		M24331			SERUM	
R	APA	124	MG/DL	1:36	1.2	
L	APB	101	MG/DL	1:36		
31		M24354			SERUM	
R	APA	130	MG/DL	1:36	1.3	
L	APB	103	MG/DL	1:36		
32		M24359			SERUM	
R	APA	92.3	MG/DL	1:36	1.1	
L	APB	83.0	MG/DL	1:36		
~~33~~	NOT USED IN STUDY ~~D24347~~				SERUM	
R	APA	113	MG/DL	1:36		
L	APB	132	MG/DL	1:36		
~~34~~	NOT USED IN STUDY ~~D24342~~				SERUM	
R	APA	124	MG/DL	1:36		
L	APB	77.4	MG/DL	1:36		
35		C24356			SERUM	
R	APA	134	MG/DL	1:36		
L	APB	62.5	MG/DL	1:36	1.6	
36		D24355			SERUM	
R	APA	149	MG/DL	1:36	1.4	
L	APB	85.0	MG/DL	1:36		

Thursday, July 12
16:22

		CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS
37			D24358			SERUM	
	R	APA	119	MG/DL	1:36	1.0	
	L	APB	115	MG/DL	1:36		
38			D24360			SERUM	
	R	APA	114	MG/DL	1:36	1.0	
	L	APB	115	MG/DL	1:36		
39			C24362			SERUM	
	R	APA	142	MG/DL	1:36	1.3	
	L	APB	110	MG/DL	1:36		
40			D24361			SERUM	
	R	APA	96.5	MG/DL	1:36	1.5	
	L	APB			1:36		Unstable reaction
	L	APB	65.0	MG/DL	1:36		

Thursday, July 12
16:34

LACKLAND A.F.B.

	CHEM	RESULT	UNITS	DILUTION	AGXS	RANGE/FLAGS	
1	APA M907094				SERUM		
	L APA	90.2	MG/DL	1:36		79.00	113.0
	R APA	90.0	MG/DL	1:36		79.00	113.0
2	APB M907094				SERUM		
	L APB	118	MG/DL	1:36		100.0	130.0
	R APB	123	MG/DL	1:36		100.0	130.0
3	D24341				SERUM		
	L APA	139	MG/DL	1:36			
	R APB	117	MG/DL	1:36	1.2		
4	C24359				SERUM		
	L APA	126	MG/DL	1:36			
	R APB	72.3	MG/DL	1:36	1.8		
5	C24365				SERUM		
	L APA	112	MG/DL	1:36			
	R APB	124	MG/DL	1:36	0.9		
6	C24366				SERUM		
	L APA	136	MG/DL	1:36			
	R APB	108	MG/DL	1:36			
7	C24367				SERUM		
	L APA	146	MG/DL	1:36			
	R APB	95.1	MG/DL	1:36			
8	C24368				SERUM		
	L APA	116	MG/DL	1:36			
	R APB	121	MG/DL	1:36			

GRAPH HEADING EXPLANATION

ON THE TOP OF ALL THE GRAPHS USED IN THIS REPORT, THERE IS A SET OF STATISTICS. THE FIRST EQUATION IS THE EQUATION OF THE LINE OF THE GRAPH. THIS IS A LINEAR REGRESSION CURVE, WHICH IS A LINE DRAWN BY THE COMPUTER THAT MINIMIZES THE SUM OF THE SQUARED RESIDUALS. THIS IS A METHOD BY WHICH THE COMPUTER DETERMINES WHERE THE LINE SHOULD BE TO BEST FIT THE POINTS. THE FIRST EQUATION IS Y = MX + B, WITH "M" EQUAL TO THE SLOPE AND "B" BEING THE Y-INTERCEPT. ON THE COMPARISON GRAPHS FOUND IN THE APOLIPOPROTEIN COMPARISON STUDY, A PERFECT CORRELATION WOULD OCCUR WHEN THE SLOPE IS ONE AND THE Y-INTERCEPT IS ZERO.

THE NEXT NUMBER IS THE ROOT MEAN SQUARE ERROR. THIS NUMBER IS A MEASURE OF HOW WELL THE LINE FITS THE POINTS, IN UNITS FOUND ON THE Y-AXIS. THE UNITS OF THE Y-AXIS ARE USED BECAUSE THIS MEAN VALUE SHOWS HOW MUCH THE POINTS ARE ABOVE OR BELOW THE LINE, IN TERMS OF Y. THE ROOT MSE IS THE MEAN DISTANCE OF EACH POINT FROM THE LINE, OR THE STANDARD DEVIATION AROUND THE LINE. "R" IS THE CORRELATION COEFFICIENT. THIS MEASURES THE STRENGTH OF THE LINEAR RELATIONSHIP BETWEEN X AND Y. A CORRELATION COEFFICIENT OF +/- 1.00 WOULD INDICATE A PERFECT CORRELATION ON THE APO COMPARISON GRAPHS AND THE CAD PREDICTION GRAPHS. THE SLOPE AND Y-INTERCEPT ARE NOT AS IMPORTANT ON GRAPHS THAT DO NOT HAVE A STARTING POINT OF (0,0) AND EQUALLY SCALED AXES

BECAUSE SUCH GRAPHS, AS THOSE FOUND IN THE CAD PREDICTION STUDY, CAN HAVE PERFECT CORRELATION WITHOUT A SLOPE OF 1 OR A Y-INTERCEPT OF ZERO. . THE SQUARE OF THE CORRELATION COEFFICIENT IS ANOTHER WAY OF INTERPRETING "R". IF "R SQUARE" IS EQUAL TO .65, FOR INSTANCE, THIS WOULD MEAN THAT 65% OF THE VARIANCE ON THE GRAPH IS DUE TO THE X-AXIS. IF YOU SUBTRACT THIS VALUE FROM 1.00, THE NUMBER YOU GET, .35, IS THE PERCENT VARIANCE THAT IS ATTRIBUTED TO OTHER FACTORS. "N" IS THE NUMBER OF POINTS, OR PATIENT VALUES, USED ON THE GRAPH. THESE STATISTICS WERE USED IN DETERMINING THE CORRELATION AND RELATIONSHIPS OF ALL THE GRAPHS IN THIS REPORT.

PROGRAM DESCRIPTIONS

THE FOLLOWING PAGES ARE COMPUTER PROGRAMS I USED TO GENERATE ALL MY GRAPHS AND CHARTS. THE FIRST PROGRAM WAS USED TO CREATE THE GRAPH THAT COMPARES THE APO A-1 VALUES FROM BAFB TO THE APO A-1 VALUES FROM LAFB. THIS PROGRAM WAS ALSO RESPONSIBLE FOR CREATING THE COMPARISON CHART WITH ALL THE APO A-1, APO B, AND A-1/B RATIOS FROM BOTH BAFB AND LAFB. THE NEXT PROGRAM COMPARED THE TWO DIFFERENT SETS OF APO B VALUES. AFTER THAT, THE NEXT PROGRAM COMPARED THE A-1/B RATIOS FROM THE RESPECTIVE BASES. ALL THREE OF THESE PROGRAMS WERE USED TO PRODUCE THE "TESTING SIGNIFICANT DIFFERENCES BETWEEN PAIRED MEASUREMENTS" MEAN DIFFERENCES CHART. THE LAST PROGRAM WAS QUITE VERSATILE. THIS PROGRAM ALLOWED ME TO CREATE ALL 36 OF MY GRAPHS USED IN MY CAD PREDICTION STUDY. I ALSO WAS ABLE TO CREATE THE CHART WITH ALL MY DATA FOR THE CAD PREDICTION STUDY. THESE PROGRAMS RECEIVED THEIR INFORMATION FOR PLOTTING THE GRAPHS AND MAKING THE CHARTS FROM DATA FILES I CREATED THAT CONTAINED ALL THE PATIENTS' TEST VALUES THAT WERE TAKEN OUT OF PATIENT FILES. THE CHARTS ARE BASICALLY PRINTOUTS OF WHAT WAS IN THE DATA FILES.

```
ILENAME INDAT 'NGDISK:[ANDERSON]COMPARE.SAV';
ILENAME NEW 'NGDISK:[ANDERSON]NEWSET.SAS';
ILENAME NEWCORR 'NGDISK:[ANDERSON]NEWSETC.SAS';
ILENAME NEWN 'NGDISK:[ANDERSON]NEWSETN.SAS';
ATA PLOT;
    INFILE INDAT;
    INPUT CASENR $CHAR6. A1_WH B_WH RAT_WH A1_BRK B_BRK RAT_BRK;
roc print data=plot;
ROC REG DATA=PLOT OUTEST=COEFF NOPRINT;
    MODEL A1_BRK=A1_WH;
    OUTPUT OUT=REGOUT PREDICTED=PRED;
    TITLE1 'LINEAR REGRESSION FIT';
PROC PRINT DATA=COEFF;
ROC CORR DATA=PLOT OUTP=PCORR NOPRINT;
    VAR A1_BRK A1_WH;
ATA PEARS;
    SET PCORR;
    IF( _TYPE_ EQ 'CORR' AND _NAME_ EQ 'A1_BRK');
    CORREL=A1_WH;
    R2=CORREL*CORREL;
    KEEP CORREL R2;
ATA NUM;
    SET PCORR;
    IF( _TYPE_ EQ 'N');
    NCORR=MIN(A1_WH,A1_BRK);
    KEEP NCORR;
PROC PRINT DATA=PEARS;
PROC PRINT DATA=NUM;
ATA PUTSET;
   . SET COEFF;
    FILE NEW;
    PUT 'TITLE2 F=XSWISS C=WHITE "Y = 'A1_WH 5.2' * X + 'INTERCEP 5.2'";';
    PUT 'TITLE3 F=XSWISS C=WHITE "Root MSE = '_rmse_ 6.3'";';
ATA PUTSETC;
    SET PEARS;
    FILE NEWCORR;
    PUT 'TITLE4 F=XSWISS C=WHITE "r = 'CORREL 6.3'     rsquare = 'r2 6.3'";';
ATA PUTSETN;
    SET NUM;
    FILE NEWN;
    PUT 'TITLE5 F=XSWISS C=WHITE "n = 'NCORR 4.0'";';
ROC GPLOT DATA=REGOUT;
    SYMBOL1 V=DIAMOND COLOR=WHITE I=RL;
    AXIS1 LABEL=(F=XSWISS 'A1 WHMC')
          ORDER=0 TO 300 BY 50
          OFFSET=(0)
          LENGTH = 3.8 IN
          VALUE=(F=XSWISS);
    AXIS2 LABEL=(F=XSWISS 'A1 BROOKS')
          ORDER=0 TO 300 BY 50
          OFFSET=(0)
          LENGTH = 3.8 IN
          VALUE=(F=XSWISS);
    PLOT A1_BRK*A1_WH=1/VAXIS=AXIS2 HAXIS=AXIS1 FRAME ;
    TITLE1 F=XSWISS C=WHITE 'ALL SUBJECTS';
    NOTE1 F=XSWISS C=WHITE M=(2,21) '550 EXPRESS TURBIDIMETRIC';
    NOTE2 F=XSWISS C=WHITE M=(30,1.5) 'BECKMAN ARRAY NEPHELOMETRY';
    NOTE3 F=XSWISS C=WHITE M=(5,18) 'RIA-CHEM KIT';
%INCLUDE NEW;
%INCLUDE NEWCORR;
%INCLUDE NEWN;
*PROC PRINT DATA=REGOUT;
```

```
ILENAME INDAT 'NGDISK:[ANDERSON]COMPARE.SAV';
ILENAME NEW 'NGDISK:[ANDERSON]NEWSET.SAS';
ILENAME NEWCORR 'NGDISK:[ANDERSON]NEWSETC.SAS';
ILENAME NEWN 'NGDISK:[ANDERSON]NEWSETN.SAS';
ATA PLOT;
     INFILE INDAT;
     INPUT CASENR $CHAR6. A1_WH B_WH RAT_WH A1_BRK B_BRK RAT_BRK;
proc print data=plot;
ROC REG DATA=PLOT OUTEST=COEFF NOPRINT;
     MODEL B_BRK=B_WH;
     OUTPUT OUT=REGOUT PREDICTED=PRED;
     TITLE1 'LINEAR REGRESSION FIT';
PROC PRINT DATA=COEFF;
ROC CORR DATA=PLOT OUTP=PCORR NOPRINT;
     VAR B_BRK B_WH;
ATA PEARS;
     SET PCORR;
     IF(_TYPE_ EQ 'CORR' AND _NAME_ EQ 'B_BRK');
     CORREL=B_WH;
     R2=CORREL*CORREL;
     KEEP CORREL R2;
ATA NUM;
     SET PCORR;
     IF(_TYPE_ EQ 'N');
     NCORR=MIN(B_WH,B_BRK);
     KEEP NCORR;
PROC PRINT DATA=PEARS;
PROC PRINT DATA=NUM;
ATA PUTSET;
     SET COEFF;
     C=B_WH;
     FILE NEW;
     PUT 'TITLE2 F=XSWISS C=WHITE "Y = 'C 5.2' * X + 'INTERCEP 5.2'";';
     PUT 'TITLE3 F=XSWISS C=WHITE "Root MSE = '_rmse_ 6.3'";';
ATA PUTSETC;
     SET PEARS;
     FILE NEWCORR;
     PUT 'TITLE4 F=XSWISS C=WHITE "r = 'CORREL 6.3'     rsquare = 'r2 6.3'";';
ATA PUTSETN;
     SET NUM;
     FILE NEWN;
     PUT 'TITLE5 F=XSWISS C=WHITE "n = 'NCORR 4.0'";';
ROC GPLOT DATA=REGOUT;
     SYMBOL1 V=DIAMOND COLOR=WHITE I=RL;
     AXIS1 LABEL=(F=XSWISS 'B WHMC')
           ORDER=0 TO 200 BY 50
           OFFSET=(0)
           LENGTH = 3.8 IN
           VALUE=(F=XSWISS);
     AXIS2 LABEL=(F=XSWISS 'B BROOKS')
           ORDER=0 TO 200 BY 50
           OFFSET=(0)
           LENGTH = 3.8 IN
           VALUE=(F=XSWISS);
     PLOT B_BRK*B_WH=1/VAXIS=AXIS2 HAXIS=AXIS1 FRAME ;
     TITLE1 F=XSWISS C=WHITE 'ALL SUBJECTS';
     NOTE1 F=XSWISS C=WHITE M=(2,21) '550 EXPRESS TURBIDIMETRIC';
     NOTE2 F=XSWISS C=WHITE M=(30,1.5) 'BECKMAN ARRAY NEPHELOMETRY';
     NOTE3 F=XSWISS C=WHITE M=(5,18.5) 'RIA-CHEM KIT';
%INCLUDE NEW;
%INCLUDE NEWCORR;
%INCLUDE NEWN;
*PROC PRINT DATA=REGOUT;
```

```
ILENAME INDAT 'NGDISK:[ANDERSON]COMPARE.SAV';
ILENAME NEW 'NGDISK:[ANDERSON]NEWSET.SAS';
ILENAME NEWCORR 'NGDISK:[ANDERSON]NEWSETC.SAS';
ILENAME NEWN 'NGDISK:[ANDERSON]NEWSETN.SAS';
ATA PLOT;
     INFILE INDAT;
     INPUT CASENR $CHAR6. A1_WH B_WH RAT_WH A1_BRK B_BRK RAT_BRK;
proc print data=plot;
ROC REG DATA=PLOT OUTEST=COEFF NOPRINT;
     MODEL RAT_BRK=RAT_WH;
     OUTPUT OUT=REGOUT PREDICTED=PRED;
     TITLE1 'LINEAR REGRESSION FIT';
PROC PRINT DATA=COEFF;
ROC CORR DATA=PLOT OUTP=PCORR NOPRINT;
     VAR RAT_BRK RAT_WH;
ATA PEARS;
     SET PCORR;
     IF( _TYPE_ EQ 'CORR' AND _NAME_ EQ 'RAT_BRK');
     CORREL=RAT_WH;
     R2=CORREL*CORREL;
     KEEP CORREL R2;
ATA NUM;
     SET PCORR;
     IF( _TYPE_ EQ 'N');
     NCORR=MIN(RAT_WH,RAT_BRK);
     KEEP NCORR;
PROC PRINT DATA=PEARS;
PROC PRINT DATA=NUM;
ATA PUTSET;
     SET COEFF;
     C=RAT_WH;
     FILE NEW;
     PUT 'TITLE2 F=XSWISS C=WHITE "Y = 'C 5.2' * X + 'INTERCEP 5.2'";';
     PUT 'TITLE3 F=XSWISS C=WHITE "Root MSE = '_rmse_ 6.3'";';
ATA PUTSETC;
     SET PEARS;
     FILE NEWCORR;
     PUT 'TITLE4 F=XSWISS C=WHITE "r = 'CORREL 6.3'     rsquare = 'r2 6.3'";';
ATA PUTSETN;
     SET NUM;
     FILE NEWN;
     PUT 'TITLE5 F=XSWISS C=WHITE "n = 'NCORR 4.0'";';
ROC GPLOT DATA=REGOUT;
     SYMBOL1 V=DIAMOND COLOR=WHITE I=RL;
     AXIS1 LABEL=(F=XSWISS 'A1/B WHMC')
           ORDER=0 TO 4 BY .50
           OFFSET=(0)
           LENGTH = 3.8 IN
           VALUE=(F=XSWISS);
     AXIS2 LABEL=(F=XSWISS 'A1/B BROOKS')
           ORDER=0 TO 4 BY .50
           OFFSET=(0)
           LENGTH = 3.8 IN
           VALUE=(F=XSWISS);
     PLOT RAT_BRK*RAT_WH=1/VAXIS=AXIS2 HAXIS=AXIS1 FRAME ;
     TITLE1 F=XSWISS C=WHITE 'ALL SUBJECTS';
     NOTE1 F=XSWISS C=WHITE M=(2,21) '550 EXPRESS TURBIDIMETRIC';
     NOTE2 F=XSWISS C=WHITE M=(30,1.75) 'BECKMAN ARRAY NEPHELOMETRY';
     NOTE3 F=XSWISS C=WHITE M=(5,18) 'RIA-CHEM KIT';
INCLUDE NEW;
INCLUDE NEWCORR;
INCLUDE NEWN;
PROC PRINT DATA=REGOUT;
```

```
ILENAME INDAT 'NGDISK:[anderson]RATIO.DAT';
ILENAME NEW 'NGDISK:[anderson]NEWSET.SAS';
ILENAME NEWCORR 'NGDISK:[anderson]NEWSETC.SAS';
ILENAME NEWN 'NGDISK:[anderson]NEWSETN.SAS';
ATA PLOT;
     INFILE INDAT;
     INPUT CASENR $CHAR6. A1 B A1_B_RAT CHOL HDL C_H_RAT TRIG RISK_IDX LDL;
proc print data=plot;
ROC REG DATA=PLOT OUTEST=COEFF;
     MODEL A1_B_RAT=TRIG;
     OUTPUT OUT=REGOUT PREDICTED=PRED;
     TITLE1 'LINEAR REGRESSION FIT';
PROC PRINT DATA=COEFF;
ROC CORR DATA=PLOT OUTP=PCORR NOPRINT;
     VAR A1_B_RAT TRIG;
ATA PEARS;
     SET PCORR;
     IF( _TYPE_ EQ 'CORR' AND _NAME_ EQ 'A1_B_RAT');
     CORREL=TRIG;
     R2=CORREL*CORREL;
     KEEP CORREL R2;
)ATA NUM;
     SET PCORR;
     IF( _TYPE_ EQ 'N');
     NCORR=TRIG;
     KEEP NCORR;
PROC PRINT DATA=PEARS;
PROC PRINT DATA=NUM;
)ATA PUTSET;
     SET COEFF;
     C=TRIG;
     FILE NEW;
     PUT 'TITLE2 F=XSWISS C=WHITE "Y = 'C 5.2' * X + 'INTERCEP 5.2'";';
     PUT 'TITLE3 F=XSWISS C=WHITE "Root MSE = '_rmse_ 6.3'";';
)ATA PUTSETC;
     SET PEARS;
     FILE NEWCORR;
     PUT 'TITLE4 F=XSWISS C=WHITE "r = 'CORREL 6.3'     rsquare = 'r2 6.3'";';
)ATA PUTSETN;
     SET NUM;
     FILE NEWN;
     PUT 'TITLE5 F=XSWISS C=WHITE "n = 'NCORR 4.0'";';
)ROC GPLOT DATA=REGOUT;
     SYMBOL1 V=DIAMOND COLOR=WHITE I=RL;
     AXIS1 LABEL=(F=XSWISS ' A1_B_RATIO')
           VALUE=(F=XSWISS);
     AXIS2 LABEL=(F=XSWISS ' TRIG')
           VALUE=(F=XSWISS);
     PLOT A1_B_RAT*TRIG=1/HAXIS=AXIS2 VAXIS=AXIS1 ;
     TITLE1 F=XSWISS C=WHITE 'ALL SUBJECTS';
%INCLUDE NEW;
%INCLUDE NEWCORR;
%INCLUDE NEWN;
*PROC PRINT DATA=REGOUT;
```

APOLIPOPROTEIN COMPARISON STUDY CONCLUSION

WHEN ANALYZING DATA, IT IS EASY TO IDENTIFY THE PATTERNS AND SIMILARITIES AMONG THE INFORMATION, AND THOSE VALUES THAT DO NOT CORRELATE ARE EQUALLY AS OBVIOUS. THEREFORE, ONE OF THE MOST IMPORTANT QUESTIONS ONE CAN ASK WHEN ANALYZING DATA IS "WHY?". IN THE CASE OF THE APOLIPOPROTEIN COMPARISON STUDY BETWEEN BROOKS AFB AND LACKLAND AFB, THE VALUES THAT ARE SIGNIFICANTLY DIFFERENT ARE THE ONES THAT WE ARE CONCERNED WITH. AFTER VIEWING THE CHART THAT CONTAINS THE APOLIPOPROTEIN DATA FROM LACKLAND AND BROOKS, ONE CAN SEE THAT THE MAJORITY OF THE BROOKS VALUES ARE LOWER THAN THEIR RESPECTIVE LACKLAND VALUES. YET THERE IS A SMALL GROUP WHOSE BROOKS VALUES ARE HIGHER. SO THE "WHY?" QUESTION THAT MUST BE ASKED IS: WHY ARE SOME OF THE BROOKS VALUES HIGHER THAN THEIR RESPECTIVE LACKLAND VALUES WHEN THE MAJORITY OF THE BROOKS VALUES ARE LOWER?

IN EXPLORING THIS DISCREPANCY, I HAVE FOUND SEVERAL POSSIBLE SOLUTIONS, ALTHOUGH IT IS VIRTUALLY IMPOSSIBLE TO BE 100% SURE WHY THESE DISCREPANCIES OCCURRED. ALL OF THE CONTROLS AND CALIBRATORS ON BOTH MACHINES INDICATED THAT THE TWO MACHINES WERE OPERATING PROPERLY; YET THE VALUES DIFFER. IF THE MACHINES WERE FUNCTIONING PROPERLY, THE PROBLEM MUST BE WITH THE SERUM SAMPLE ITSELF OR THE TESTING KIT. HOWEVER, SINCE THE CONTROLS WORKED WITH THE KIT, THEN ONE WOULD HAVE TO ASSUME THAT THE KIT WORKED PROPERLY WITH THE

SAMPLES. THEREFORE, IF THE SAMPLES ARE TO BLAME, WHAT WAS WRONG WITH THEM? OUR SAMPLES WERE FROZEN PRIOR TO TESTING AT -26 DEGREES CELSIUS. BECAUSE WE ONLY RECEIVE A FEW NEW PATIENT SAMPLES EVERYDAY, WE HAVE TO WAIT A MONTH BEFORE WE HAVE A BATCH TO RUN THE APO TESTS ON. BEING FROZEN FOR VARIED LENGTHS OF TIME COULD OF HAD AN EFFECT ON THE SPECIMENS. ALSO, THE IDEAL TEMPERATURE FOR FREEZING THESE SAMPLES IS ACTUALLY -70 DEGREES CELSIUS. THIS DISCREPANCY IN FREEZING TEMPERATURE COULD ALSO HAVE SOME EFFECT ON THE SAMPLES. HOWEVER, SINCE THIS TYPE OF TESTING IS BRAND NEW TO THE AIR FORCE, MANY THINGS ARE YET TO BE DISCOVERED. THE FREEZING OF THESE SPECIMENS COULD HAVE ALSO CAUSED THE APOLIPOPROTEINS TO CONGLOMERATE. IF THE MACHINE WERE TO ASPIRATE ONE OF THESE CONGLOMERATIONS, IT WOULD CAUSE THE READING TO BE OFF. I BELIEVE THAT THE BEST SOLUTION TO THIS PROBLEM WOULD BE TO START THIS RESEARCH OVER. THIS WAY, ALL THE SAMPLES COULD BE RUN FRESH, A SYSTEM OF CONTROLS COULD BE SET UP TO INSURE THAT ALL THE SAMPLES ARE TREATED EQUALLY, AND VARIOUS KITS COULD BE TRIED TO FIND THE ONE THAT DELIVERS THE BEST RESULTS IN COMPARISON TO THE BECKMAN ARRAY AT WILFORD HALL MEDICAL CENTER, LACKLAND AIR FORCE BASE.

CAD PREDICTION STUDY CONCLUSION

BY ANALYZING THIRTY SIX GRAPHS THAT COMPARED DIFFERENT APOLIPOPROTEINS, LIPIDS, AND RATIOS, I WAS ABLE TO DETERMINE THE RELATIONSHIP AMONG THE NINE DIFFERENT ELEMENTS IN THE STUDY. I DISCOVERED THAT MANY OF THE ELEMENTS HAVE NO RELATIONSHIP TO EACH OTHER, SUCH AS APO A-1 VS. APO B OR HDL CHOL VS. TOTAL CHOLESTEROL. IN SOME, I WAS SURPRISED TO SEE SUCH GOOD CORRELATION. SUCH A GRAPH WOULD BE APO B VS. TOTAL CHOLESTEROL. HOWEVER, THE GRAPHS THAT WERE THE MOST INTERESTING WERE THE ONES THAT WERE NOT SO EASY TO DETERMINE IF THEY CORRELATED OR NOT. THIS IS A CATEGORY THAT QUITE A FEW OF THE GRAPHS FELL INTO. ON THE WHOLE, I DO NOT FEEL THAT ANY OF THESE GRAPHS PROVIDED ANY STARTLING REVELATIONS INTO THE FIELD OF CAD PREDICTION RESEARCH. I DO BELIEVE THAT THEY DID PROVE THAT THERE IS VALID RELATIONSHIPS AMONG THESE DIFFERENT VALUES. I ALSO BELIEVE THAT ONE CONCLUSION THAT CAN BE DRAWN FROM THIS COMPARISON STUDY IS THAT ALL OF THESE ELEMENTS ARE IMPORTANT IN THE PREDICTION OF CAD. ALTHOUGH THE A-1/B RATIO MAY BE THE BEST SOLITARY PREDICTOR OF CAD, USING ALL OF THESE FACTORS SHOULD PROVIDE THE BEST OVERALL PREDICTION OF CAD. INSTEAD OF USING ALL NINE FACTORS INDIVIDUALLY, THEY COULD BE USED IN CONJUNCTION WITH EACH OTHER IN THE RELATIONSHIPS DISCOVERED BY THIS STUDY TO PROVIDE THE BEST AND MOST ACCURATE METHOD FOR PREDICTING CAD KNOWN TO MAN.

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HIGH SCHOOL APPRENTICESHIP PROGRAM FINAL REPORT

SONYA LONGBOTHAM

BROOKS AEROSPACE MEDICAL LAB (D.E.B.L.)

SAN ANTONIO, TEXAS

18 JUNE - 24 AUGUST, 1990

ACKNOWLEDGEMENTS

I'd like to hand an extra special thanks to LTC Mickley, Ms. Brenda Cobb, and SSG Nemeth for involving me in a meaningful way in their work and for their friendship throughout. Thanks guys!

I. Introduction

My ten week apprenticeship at Brooks Aerospace Medical Lab (Directed Energy Bioeffects Laboratory - D.E.B.L.) included assistance on two projects and three primary technical functions.

II. Projects Assisted

A. Habituation of Experimental Animals

Radiation induced neuro-physiologic experiments on rats are subject to a variety of pre-experimental variables including animal stress. Our experiment, (Brenda Cobb's + my assistance), required manual placement of test animals into individual radiation holders, which are subsequently placed into an anachoic chamber. To control for pre-chamber stress, the test animals were habituated to one handler, one method of holding and chamber placement. Habituation (level of stress) was measured by counting the stress "pellets" and their liquid counterparts excreted by each animal during a twenty minute time period. [Refer to *Restraint Data* (inclusion #1). Note: the numerator represents the liquid form of stress (it's presence or absence) and the denominator represents each individual stess "pellet"]. After a fourteen-day habituation period the number of stress

signals decreased to zero for seventy percent of the animals.

B. Cell Counts on Radiated and Nonradiated Tissue.

Experimental radiation induced injury to a specific locus of the brain (hippocampus) was facilitated by lead blocks placed to protect other areas of the brain (olfactory bulb and cerebellum) from radiation. This technique was criticized for lack of proof of protection of the blocked regions. Therefore, objective cell counts of radiated and nonradiated regions of the brain were undertaken to document cell loss in the blocked versus the unblocked portion of the brain. Many controls were used including sham/irradiation technique, the presence or absence of surgery, and sham surgery (cranium incised but no tissue damaged). Cell counts were performed on formalin fixed, parafin embedded sections on a light microscope using an ocular micrometer. Raw cell counts were corrected for surface area and section thickness. [See highlighted columns of inclusions #2 and #3. Note: Inclusion #2 is the sham irradiated animals and inclusion #3 represents the radiated animals.] Conclusions for this project are included in a separate report (by LTC Mickley).

III. Technical Functions Performed.

A. Decapitation of Practice and Experimental Animals.

At the completion of numerous tests and radiation procedures, rats were sacrificed by decapitation to obtain brain tissue for objective quantitation of experimental effects. A razor sharp guillotine was used. Rats were fully anesthetized.

B. Assist at Brain Surgery on Experimental Rats.

Assistance was provided for two different procedures. In the first, sterile plastic cannulae were placed 2.8 mm posterior to bregma at a depth of 3.0 mm. These cannulae provided later use as a passage for brain probes. The cannulae were stabilized by way of four screws (plastic) and adhered to the cranium by dental cement. The second surgery procedure was placement of a single plastic cannula for subsequent passage of a temperature probe. The cannula was filled with saline when not in use.

C. General Care Of Experimental Animals.

These functions include:

- feeding and watering
- socialization
- transportation
- cage care

IV. Summary

Assisting with a variety of experiments and performing technical functions gave me an introduction to experimental design and experimental controls. Working as a group accentuated morale and team support.

REFERENCES

none.

Date	Rat # 1	2	4	5	9	10	11	12	13
7/16	0/0	1/4	0/2	0/2	0/0	0/4	1/0	1/2	1/0
7/17	1/3	1/6	0/5	0/0	0/0	0/2	0/1	0/4	0/0
7/18	0/0	0/0	0/2	0/0	0/4	0/0	0/1	0/1	0/2
7/19	1/3	1/6	0/4	1/5	0/0	0/2	0/1	0/0	0/1
7/20	1/0	1/0	0/3	1/1	0/0	0/3	0/0	0/1	0/0
7/23	0/4	1/2	0/6	0/4	0/0	0/0	1/2	0/0	1/2
7/24	0/0	1/4	0/1	0/1	0/0	0/0	0/0	1/3	1/1
7/25	1/0	1/1	0/2	0/0	0/	0/	0/0	0/2	0/1
7/26	0/0	1/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
7/27	0/0	1/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
7/30	0/0	0/1	0/0	0/0	0/0	0/0	0/0	0/0	0/0
7/31	0/1	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8/2	0/0	0/0	0/1	0/15	0/0	0/0	0/1	0/0	1/3
8/3	0/0	0/3	0/3	0/	0/0	0/	0/0	0/0	0/0

NEONATALLY IRRADIATED RATS - YOUNG TRANSPLANT GROUP

0 ANIMAL #	1 SLIDE #	2 RAD/SHAM	3 SURGERY	4 DG AREA	5 DG CELL TOTALS
1 376R	R168	2	3	1.660	1515
2 380R	R120	2	3	1.700	1664
3 388L	L15	2	3	2.186	1162
4 393R	R10	2	3	2.470	1857
5 404L	L5	2	3	2.837	2124
6 426L	L9	2	3	2.739	2429
7 442R	R18	2	3	2.594	1463
8 447R	R7	2	3	3.241	1854
9 461L	L20	2	3	2.458	1313
10 465L	L12	2	3	2.044	979
11 383R	R20	2	4	2.710	1522
12 392L	L13	2	4	2.428	1304
13 405R	R16	2	4	2.511	2059
14 427R	R20	2	4	2.842	1549
15 449R	R16	2	4	2.406	1154
16 462R	R21	2	4	2.162	1247
17 451R	R6	2	3	1.847	944

0 ANIMAL #	6 DG DENSITY	7 DG CELL THICKNESS	8 CA1 CELL THICKNESS	9 OB COUNT
1 376R	912.65000	6.33	1.50	506
2 380R	978.82000	4.87	2.50	825
3 388L	531.56000	8.00	2.17	610
4 393R	751.82000	8.00	1.83	609
5 404L	748.68000	8.00	2.00	498
6 426L	887.14000	7.50	2.83	685
7 442R	563.99000	5.67	2.67	767
8 447R	572.05000	6.00	2.00	507
9 461L	534.17000	4.00	2.33	592
10 465L	478.96000	4.87	2.67	555
11 383R	561.63000	7.00	2.83	733
12 392L	537.07000	8.67	2.33	377
13 405R	819.99000	6.67	2.67	472
14 427R	545.04000	6.00	2.83	400
15 449R	479.63000	4.67	1.67	538
16 462R	576.78000	4.50	3.00	708
17 451R	511.09908	5.83	2.17	552

NEONATALLY IRRADIATED RATS - YOUNG TRANSPLANT GROUP

0 ANIMAL #	10 OB C-AREA	11 OB DENSITY	12 CB COUNT	13 CB C-AREA	14 CB AREA
1 376R	0.051	9921.568627	1133	0.051	23.0
2 380R	0.051	16176.470588	1128	0.051	18.3
3 388L	0.051	11960.784314	1176	0.051	22.2
4 393R	0.051	11941.176471	751	0.051	24.9
5 404L	0.051	9764.705882	735	0.051	31.3
6 426L	0.051	13431.372549	943	0.051	22.3
7 442R	0.051	15039.215686	861	0.051	21.0
8 447R	0.051	9941.176471	929	0.051	20.6
9 461L	0.051	11607.843137	920	0.051	21.9
10 465L	0.051	10882.352941	987	0.051	21.5
11 383R	0.051	14372.549020	946	0.051	17.7
12 392L	0.051	7392.156863	969	0.051	4.8
13 405R	0.051	9254.901961	878	0.051	22.4
14 427R	0.051	7843.137255	819	0.051	24.3
15 449R	0.051	10549.019608	849	0.051	20.7
16 462R	0.051	13882.352941	823	0.051	19.2
17 451R	0.051	10823.529412	777	0.051	23.7

0 ANIMAL #	15 CB DENSITY
1 376R	22215.686275
2 380R	22117.647059
3 388L	23058.823529
4 393R	14725.490196
5 404L	14411.764706
6 426L	18490.196078
7 442R	16882.352941
8 447R	18215.686275
9 461L	18039.215686
10 465L	19352.941176
11 383R	18549.019608
12 392L	19000.000000
13 405R	17215.686275
14 427R	16058.823529
15 449R	16647.058824
16 462R	16137.254902
17 451R	15235.294118

NEONATALLY IRRADIATED RATS - YOUNG TRANSPLANT GROUP

0 ANIMAL #	1 SLIDE #	2 RAD/SHAM	3 SURGERY	4 DG AREA	5 DG CELL TOTALS
1 382R	R136	1	3	1.010	494
2 396L	L13	1	3	0.488	82
3 423R	R13	1	3	0.934	233
4 431R	R18	1	3	0.698	132
5 432L	L21	1	3	0.599	93
6 438L	L9	1	3	0.896	266
7 445L	L13	1	3	0.902	295
8 401R	R15	1	4	0.699	197
9 409R	R18	1	4	1.135	248
10 425L	L8	1	4	0.518	135
11 429R	R15	1	4	0.639	114
12 433R	R18	1	4	0.758	116
13 439L	L12	1	4	0.950	276
14 446R	R4	1	4	0.932	322
15 453R	R17	1	4	1.546	489
16 454L	L14	1	4	0.974	221
17 466L	L15	1	4	0.856	134

0 ANIMAL #	6 DG DENSITY	7 DG CELL THICKNESS	8 CA1 CELL THICKNESS	9 OB COUNT
1 382R	489.108911	2.00	2.67	816
2 396L	168.032787	1.83	2.17	601
3 423R	249.464668	2.50	2.67	466
4 431R	189.111748	1.50	2.67	375
5 432L	155.258765	2.17	1.33	499
6 438L	296.875000	3.33	4.33	688
7 445L	327.050998	1.87	1.83	
8 401R	281.831187	2.83	2.17	489
9 409R	218.502203	2.83	3.33	503
10 425L	260.617761	1.33	1.33	536
11 429R	178.403765	2.17	2.67	422
12 433R	153.034301	1.87	1.50	556
13 439L	290.526316	2.17	2.67	448
14 446R	345.493562	2.00	3.67	544
15 453R	316.300129	3.17	3.00	
16 454L	226.899384	1.87	2.17	471
17 466L	156.542056	2.17	1.67	399

NEONATALLY IRRADIATED RATS - YOUNG TRANSPLANT GROUP

0 ANIMAL #	10 OB C-AREA	11 OB DENSITY	12 CB COUNT	13 C-AREA	14 CB AREA
1 382R	0.051	16000.000000	1056	0.051	19.6
2 396L	0.051	11784.313725	756	0.051	14.9
3 423R	0.051	9137.254902	703	0.051	20.4
4 431R	0.051	7352.941176	749	0.051	20.6
5 432L	0.051	9784.313725	799	0.051	20.0
6 438L	0.051	13490.196078	665	0.051	28.7
7 445L	0.051		802	0.051	25.6
8 401R	0.051	9588.235294	709	0.051	20.8
9 409R	0.051	9862.745098	747	0.051	16.3
10 425L	0.051	10509.803922	1061	0.051	25.8
11 429R	0.051	8274.509804	755	0.051	23.3
12 433R	0.051	10901.960784	648	0.051	23.7
13 439L	0.051	8784.313725	849	0.051	23.0
14 446R	0.051	10666.666667	1097	0.051	22.2
15 453R	0.051		738	0.051	16.8
16 454L	0.051	9235.294118	792	0.051	23.7
17 466L	0.051	7823.529412	790	0.051	26.7

0 ANIMAL #	15 CB DENSITY
1 382R	20705.882353
2 396L	14823.529412
3 423R	13784.313725
4 431R	14686.274510
5 432L	15666.666667
6 438L	13039.215686
7 445L	15725.490196
8 401R	13901.960784
9 409R	14647.058824
10 425L	20803.921569
11 429R	14803.921569
12 433R	12705.882353
13 439L	16647.058824
14 446R	21509.803922
15 453R	14470.588235
16 454L	15529.411765
17 466L	15490.196078

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FINAL REPORT

DETERMINATION OF OPTIMUM GROWTH AND STRAIN FACILITIES FOR DIAZOTYROSINE PRODUCTION

Prepared by:	BRIAN G. McBURNETT
Academic Rank:	HIGH SCHOOL SENIOR
School:	SAMUEL CLEMENS HIGH SCHOOL
Research Location:	BROOKS AFB
	SAM/RZP
	SAN ANTONIO, TEXAS 78235
USAF Researcher:	JILL E. PARKER, PH.D.
Date:	AUGUST 10, 1990

ABSTRACT

The nitrate to nitrite oxidation property of E. coli was implemented in an attempt to form diazomelanin. The capability of different E. coli to utilize this reaction was tested through the inoculation of agar slants containing potassium nitrate and various 3-AT concentrations. Three E. coli strains were used (HB101, LE392, and C600). After 48 hours of incubation at 37°, the slants in the lower 3-AT concentrations exhibited different levels of growth and browning. No growth was seen after 48 hours in the slants containing higher 3-AT concentrations. After 72 hours, some of the colonies darkened. At the higher 3-AT concentrations only one slant displayed growth and slight browning after 72 hours. A similar experiment was also performed under anaerobic conditions at 37° with the strains LE392, C600, and MC1061. After 120 hours, all but one of the strains showed growth in the higher concentration of 3-AT slants. The slants were then exposed to aerobic conditions at 37° for 72 hours and all three strains showed growth and browning at all concentrations of 3-AT with one exception which showed no growth. Electrophoresis of endonuclease digested DNA from cells grown on the slants with 3-AT and nitrate and from untreated parent colonies showed variation in the banding pattern with ethidium bromide staining. This data illustrates that the DNA of the strains is changed during the nitrate reduction. E. coli can be used to produce diazomelanin but is inhibited by the type of strain and the antibiotic property of 3-AT.

INTRODUCTION

A thermochemiluminescent compound, diazoluminomelanin, has previously synthesized by organic means. This material is useful as a thermal and radiofrequency radiation dosimeter. Furthermore, it is a substrate for cytochrome b's of red (green hemoprotein) and white (cytochrome b559 of NADPH oxidase) blood cells. It also has potential use as a luminescent label for proteins and nucleic acids. Diazoluminolmelanin (DALM) is primarily composed of diazotyrosine that spontaneously forms diazomelanin. Diazotyrosine is formed from the combination of nitrite and 3-amino-L-tyrosine (3-AT). Diazomelanin is formed from diazotyrosine through an oxidation reduction reaction (Kiel et al., 1990). The purpose of this experiment is to have an E. coli produce this melanin. Other studies have produced melanin in E. coli cells containing plasmids (della-Cioppa, 1990). 3-AT has been found to cause pigment production in strains of legionellaceae.

OBJECTIVES

The goal of this experiment was to replicate DALM in an in vivo system using the nitrate reductase system of bacteria. The research is directed towards the formation of colonies that have been genetically altered to produce the melanin pigment. The objective of this project was to find an optimum strain of cells for nitrate to nitrite metabolism and to find the highest level of 3-AT that would not become toxic to the cells. The results will be used in order to establish direction for further experimentation.

MATERIALS AND METHODS

MEDIA

The media used consisted of yeast extract (3 g/l), tryptone (5 g/l), potassium nitrate (1 g/l), and agar (12 g/l) (Difco, 1953). After being autoclaved, 0.2 mM 3-AT and 0.4 mM 3-AT was added to separate 100 ml solutions. Twenty slants were poured. Each test tube contained 10 ml of media and was tipped at an angle and allowed to set.

BACTERIAL STRAINS

The strains used in this experiment are Escherichia coli HB101 (J. Mol. Bio., 1969), HB101 with the plasmid pSP18 (Kassavetis, et al., 1982), LE392 with the plasmid pMS1 (Oskarsson, et al., 1980), C600 with the plasmid pK2 (Srinivasan et al., 1981), MC1061 with the pc-fos(rat)-1 plasmid, and JM109 (Gene, 1985).

EXPERIMENT I

Ten test tubes (5 at 0.2mM 3-AT, 5 at 0.4mM 3-AT) were inoculated with four different bacteria (HB101/pSP18, HB101, LE392/c-mos, and C600/v-alb1). The remaining two tubes were used as a control. After inoculation the slants were placed in a 37^{o} water bath. Observations on growth and color changes were recorded after two, three, and five days.

EXPERIMENT II

The experiment was repeated with 3-AT concentrations of 0.2mM and 0.3mM. Ten test tubes (5 at 0.2mM 3-AT, 5 at 0.3mM 3-

AT) were inoculated with Cmos, Vabl1, Cfos (rat), and JM109. There were two control tubes. Cfos (rat) is from the MC1061 strain, and JM109 is another strain. The tubes were sealed in a vacuum chamber, and the oxygen was burned out by sealing a lighted candle inside the chamber and letting it burn itself out. The cells were then incubated at 37^{o} for 5 day. Observations were recorded. Air was then allowed into the chamber and the cells were allowed to grow aerobically for three additional days. Results were recorded.

DNA PREPARATION

A bacteria colony from the 0.2mM 3-AT concentration of Experiment II was grow up in 2 ml of LB broth with tetracycline overnight. A colony from the parent LB TET plate was also grown up in 2 ml LB + tetracycline overnight. Both culture were spun for 15 seconds, the supernatant was removed, and the pellets were then resuspended in 50 ul of STET (8% Sucrose, 5% Triton X-100, 50mM EDTA, and 50mM Tris pH 8.0) and vortexed. Four ul of lysozyme (10 ug/ml dissolved in H_2O) were added. The tubes were vortexed and then placed in a boiling water bath for 80 seconds and spun for 10 minutes. The supernatant was removed to a clean Eppendorf tube, and an equal volume of Isopropanol was added to the supernatant and mixed. The solutions were frozen in the $-70^{o}C$ for an hour, spun for 10 minutes and dried. The pellets were resuspended in 30 ul of H_2O.

DNA DIGESTION

The digest consisted of 5 ul of DNA from the respective tubes, 1 ul BSA, 0.2 ul of enzyme (BamH1), 1 ul DTT, 1 ul

10XBuffer (#3), and 1.8 ul of H_2O. The digests were left for one hour at 37^{o}. A 1% agarose gel containing 5 ul of ethidium bromide was made. To each sample 5 ul of DNA dye was added and the samples loaded on thee gel. A 5 ul sample of uncut DNA from each tubes with 5 ul of dye was run in adjacent wells and standard DNAs (phiX174RF cut with HaeIII and lambda DNA cut with HindIII) were run as molecular weight standards. The gel was photographed using a transilluminator. Resulting bands were recorded after viewing under ultraviolet light.

RESULTS NG=no growth +=growth B=browning
t=growth on top of slant only C=colored colonies

EXPERIMENT I

Day 2	Control	HB101/ pSP18	HB101	LE392/ c-mos	C600/ v-albl
0.2 3-AT	NG	+	+	+B	+B
0.4 3-AT	NG	NG	NG	NG	NG
Day 3					
0.2 3-AT	NG	+	+	+B	+B
0.4 3-AT	NG	NG	NG	NG	+B
Day 5					
0.2 3-AT	+B (mold)	+B	+B	+B	+B
0.4 3-AT	NG	NG	NG	NG	+B

EXPERIMENT II

ANAEROBIC Day 5	Control	LE392/ c-mos	C600/ v-albl	MC1061/ c-fos (rat)	JM109
0.2 3-AT	NG	+B	+	+	+B (mold)
0.3 3-AT	NG	+	NG	t	+B

AEROBIC
Day 8

0.2 3-AT	NG	+BC	+B	+B	+B (mold)
0.3 3-AT	NG	+B	NG	tB	+B

DNA PREPARATION

Four lanes were run. The bands from the digested and undigested DNA from the parent colonies were identical. The bands from the digested and undigested DNA from the slants were also identical, but there appeared to be differences in the banding patterns obtained with BamHI in the colonies obtained from the bacteria grown from the slant (nitrate/3-AT exposed) to those of the parent colonies.

CONCLUSIONS

Examination of the results leads to several conclusions. First, through the darkening of the media it is evident that nitrate metabolism is occurring. It can also be determined that the metabolism is restricted by the type of strain that was used. The LE392 strain containing a plasmid with a c-mos fragment seemed to brown the media often overnight while HB101 and HB101 with a pSP18 plasmid took several days to produce the same effect.

The level of 3-AT also has a toxic effect upon the cells. No growth was evident in the higher concentrations of 3-AT. Only one strain of cells grew in the 0.4mM 3-AT concentrations after 5 days of incubation. A concentration of 0.2mM 3-AT seem to produce the best results. At 0.3mM 3-AT the growth and darkening of the media were slowed by one day.

The ethidium bromide gel showed evidence of DNA damage.

Because of the different arrangement of bands between the parent colonies and the colonies from the slant, it was determined that the DNA from the slant was damaged due to its reaction between the potassium nitrate and 3-AT in the media. The damage proved not to be fatal however because of confluent growth in 2 ml of LB broth.

ACKNOWLEDGMENTS

I am very grateful of the Air Force Systems Command, Air Force Office of Scientific Research, and Universal Energy Systems for the opportunity to experience another challenging eight weeks at Brooks Air Force Base.

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SERUM FACTOR — INDUCED EXPRESSION OF THE C-FOS GENE IN NIH 3T3 CELLS

by
Heather L. Neville
Mentor: Dr. Michael Rea
Neuroscience Laboratory
Aerospace Research Branch
USAF School of Aerospace Medicine
Brooks Air Force Base, Texas

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I offer my greatest thanks to all of the wonderful people I met this summer who made my experience interesting and fun. I especially thank Dr. Michael Rea, my mentor, who taught me so much and yet, at the same time, let me learn and discover on my own so that I could gain the most out of my experience. I also give great thanks to Dr. Jill Parker, who was so patient with me and who gave me so much time and help while working with the cells. The people in the lab were especially wonderful. They also taught me, helped me when I needed it, and made the summer fun. Thanks go to: Kathryn Hart, Anna Marie Michelle, Sveta Singh, Heather Alexander, and Dr. Lew Lutton.

INTRODUCTION

The effect of serum growth factors on the expression of the c-FOS gene in NIH 3T3 cells was studied by using immunocytochemical and SDS polyacrylamide gel electrophoresis (PAGE) methods. The goal of the project was to develop a positive control for future PAGE studies of c-FOS gene expression.

In mammals, a biological clock controls daily behavioral rhythms, such as drinking and eating, sleeping and waking, and maintenance of body temperature. These rhythms are referred to as circadian rhythms, from the Latin "circa" (about) and "dies" (day). The circadian clock is located in the hypothalamus of the brain, within a region known as the suprachiasmatic nuclei (SCN). The pacemaker is normally entrained to the solar cycle, such that daily rhythms are synchronized to the environmental light-dark cycle. This is apparent in man, who normally wakes at dawn and is productive during the day, as well as nocturnal animals, like the hamster, which sleep during the day and are active at night, when they are shielded from their predators by darkness.

In the laboratory, the photic effects on the clock are studied by resetting the pacemaker using brief light pulses. When the hamster circadian pacemaker has undergone a re-setting, the result can be detected by phase shifts in the free-running activity rhythm. Dr. Rea and his co-workers at the Neuroscience Laboratory have obtained evidence that phase shifts may be caused by the action of the c-FOS gene. Some of the questions that scientists are interested

in investigating are: What is the biochemistry of light-induced FOS expression? What are FOS proteins and what are their functions?

One experimental approach used to study proteins is called western blot analysis of protein. First, proteins are separated by polyacrylamide gel electrophoresis (PAGE). The gel separates proteins by their molecular weights and forms bands of protein in the gel itself. Next, the proteins are transferred from the gel to a nitrocellulose membrane. The proteins are detected by incubating in a FOS anti-serum which binds only to FOS-related proteins. Immunoreactive protein bands can be visualized using either fluorescent or enzyme-linked second antibodies which, in turn, bind to the FOS antibody.

Before the western analysis of light-induced FOS proteins in the hamster SCN could proceed, it was necessary to test these new methods using a reliable procedure for FOS protein induction. Tom Curran et.al.,(1984) reported that FOS proteins are produced in serum-deprived (starved) NIH 3T3 fibroblasts after 2 hours of exposure to growth factor-containing serum. We used this procedure to produce FOS proteins for use as positive control material for PAGE/western blot analysis.

RESEARCH METHODS

NIH-3T3 Fibroblast Culture Procedure

Unless otherwise indicated, all procedures were sterile and took place in a Laminar flow hood using sterile media, pipettes, containers, and surfaces.

A NIH-3T3 fibroblast culture was obtained from Dr. Jill Parker (USAFSAM) and split (approximately 70% confluent) 1:10 with RPMI Media 1640 (Sigma company) containing Phenol red. The growth factor in the medium was 10% heat-deactivated (56° for 30 min.) fetal bovine serum (FBS). The old medium in the dish was aspirated to waste. Dishes were then washed with phosphate-buffered saline (PBS). Trypsin, which caused the cells to detach from the surface of the culture dish, was added and the cells were incubated at 37°C for 10 minutes. The cells were suspended in the trypsin solution and transferred to a sterile 15 ml centrifuge tube. Next, the dish was washed with the RPMI medium (10% FBS) and this was added to the tube. The cells were spun at 1200 RPM for 7 minutes using a DYNAC 2 centrifuge, and immediately following centrifugation, the supernatant was decanted. The cell pellet was re-suspended in 10 ml of medium by repeated pipetting and 1 ml of cell suspension was transferred (1 ml into each dish) to dishes containing 9 ml of fresh RPMI medium with 10% FBS. All dishes were maintained in a carbon dioxide incubator at 37°C until they were approximately 40-60% confluent (approximately 3-5 days).

FOS-Induction Experiments

To begin the starvation procedure, all of the old medium was discarded and all dishes were washed with PBS. Each dish received 10 ml of RPMI

medium with only 0.5% FBS. Two days later, all dishes were removed from the incubator and divided into 2 groups. One group was fed with 10 ml of medium containing 20% FBS (stimulated) and the other group was fed with RPMI medium containing only 0.5% FBS (control). Both groups were placed into the incubator for two hours. After incubation, all dishes were removed and washed with PBS. A single stimulated dish and a single control dish were processed for immunocytochemistry and the rest of the dishes were used for the protein chemistry experiment.

Immunocytochemistry

The purpose of the immunocytochemistry experiment was to ensure that the c-FOS gene was indeed expressed. Two plates (one control and one stimulated) were selected and washed using a non-sterile PBS buffer. Fibroblast cells were fixed to the bottom of the culture dishes using 4% paraformaldehyde. The cells were incubated in FOS anti-serum (1:5000) overnight.

Indirect-Immunofluorescence Technique

After incubation, the anti-serum was removed and an FITC-conjugated antirabbit serum was added to each plate. Both dishes were incubated in the FITC serum for 0.5 hr. The cells were washed using a non-sterile PBS-glycine buffer and a solution containing 90% glycerol and Tris/HCl was added to each dish. The culture plates were examined under a microscope with UV light to observe the fluorescence of FOS-containing cell nuclei.

Immunoperoxidase Technique

The immunoperoxidase experiment had, basically, the same purpose as the immunofluorescence; to make sure that FOS protein was produced. This method, which is more sensitive than immunofluorescence, produces cells that are darkly stained by the avidin-biotin complex (ABC). This procedure was also non-sterile. A Vecta-Stain ABC kit was used which contained all of the antibodies and reagents needed.

To begin the peroxidase experiment, the cells were fixed just as they were during the immunofluorescence experiment using paraformaldehyde. Next, the cells were incubated in the FOS anti-serum. After incubation in the antiserum, cells were washed and incubated with a second antibody(biotin-conjugated goat anti-rabbit IgG) for 1 hour at room temperature. The secondary antibody was removed and the cells were washed in buffer. The ABC reagent [avidin-biotinylated horseradish peroxidase (HRP) macromolecular complex] was added and incubated for 1 hour at room temperature. The avidin binds to the biotinylated secondary antibody. The last step was to incubate the cells in a peroxidase-substrate solution containing diaminobenzidine (DAB). The HRP catalyzes the oxidation of the DAB to produce a dark brown precipitate that reveals the location of the protein complex. The peroxidase-substrate solution was discarded and the cells were washed with PBS-glycine buffer. If the experiment was successful, FOS-immunoreactive cell nuclei would be darkly stained. It was concluded that the experiment worked best when the cells were grown on glass eight-well culture slides. When using the slide, the same procedure was followed. The dishes or culture slides were observed using regular light microscopy.

Nuclear Isolation for PAGE Electrophoresis

The first step in getting the protein chemistry experiment underway was to aspirate all of the 20% FBS medium or the 0.5% FBS medium, after the dishes had been in the incubator for two hours (as in the stimulation/control procedure seen above). All dishes were washed with cold, non-sterile PBS buffer (the procedure is no longer sterile) and placed on ice. The chilled buffers and ice were used to keep the cells and their proteins stable. Dishes were washed with a minimal amount of cold HEPES/DTT buffer (pH 7.4). Next, the cells, along with the HEPES/DTT, were scraped into centrifuge tubes and immediately placed on ice. Two centrifuge tubes were used- one for the stimulated group and one for the control group. The cells were disrupted by repeated pipetting with glass Pasteur pipettes. In the case that the weights of the tubes were uneven, the tubes were balanced using HEPES/DTT. The cells were centrifuged at 2700 RPM (600xg) at 5°C on a TOMY centrifuge for five minutes. After centrifugation, the supernatant was discarded and the pellets, consisting of cell nuclei, were frozen at -80°C. The pellets were used as positive control material for SDS-PAGE and western blot analysis in the laboratory.

RESULTS

Immunofluorescence

Numerous immunofluorescent cell nuclei were initially observed only in the stimulated NIH 3T3 cells. The intensity of the fluorescence was not as great as expected. Furthermore, after approximately 30 minutes at 4°C, no difference in fluorescence intensity between the control and stimulated cultures could be discerned.

Immunoperoxidase

As observed after immunofluorescence staining, most of the cell nuclei in both the control and stimulated dishes were labeled (figure 1) . No effect of incubation in 20% FBS was apparent. One possible explanation for the lack of stimulation is that the FBS used may have been so enriched in FOS-inducing growth factors that 0.5% FBS was sufficient to maximally induce FOS. Alternatively, the cells may not have been responsive to FBS-containing growth factors due, possibly, to suboptimal culture conditions. Nonetheless, the results demonstrated the presence of FOS-immunoreactive proteins in the nuclei of cultured fibroblasts. Therefore, PAGE and western analysis was performed using the NIH 3T3 cell nuclei.

Western Analysis of NIH 3T3 cell nuclear proteins

Western analysis after separation of fibroblast nuclear proteins on 10% polyacrylamide gels (figure 2) showed the presence of three immunoreactive bands with molecular weights appearing to be approximately 90Kd, 64Kd, and

45Kd, respectively. Preabsorbtion of the FOS antiserum with synthetic FOS m-peptide resulted in the loss of the entire 45Kd band. This result demonstrates that at least the 45Kd band represents a FOS-related protein. This finding is in partial agreement with the work of Tom Curran,et.al.(1984).

Other Interesting Experiences

During the course of the summer, many things were accomplished in the laboratory. Other than the experiments which led to the writing of the final report, additional observations and experiences were accomplished.

One of these experiments was to take part in an experiment dealing with small rodents and the setting of their circadian clocks. Many cages were prepared for the animals, each being equipped with a small box-cage and a running wheel. Two magnets were mounted on each wheel and hooked up to a computer to monitor revolutions of the wheel. When the cages were ready, male Syrian hamsters were placed into the cages (one per cage). Prior to the beginning of the experiment, all animals had been quarantined in the same room which had artificial lighting on cycles similar to that of the natural environment. The purpose of this was to synchronize all of the animals' pacemakers. Once all of the animals had been placed in their cages, the lights in the room were turned off and remained off for approximately 5 weeks. During this time, the animals were fed and taken care of in darkness. While the five weeks passed, the hamsters' circadian timekeepers were free-running. The computer recorded activity cycles by rotations of each wheel every twenty-four hours. It was apparent after only a brief time that the pacemakers were already setting their own times very similar to that of the environment despite the fact that the animals were kept in constant darkness. When the five weeks had been completed, each animal was placed under a soft lighting apparatus and was kept in this light for fifteen minutes. The purpose was to create what is known as a phase-shift in activity. Dr. Rea and his co-workers in the laboratory believe that light pulses can re-set the circadian clock and cause a definite

change in activity rhythms. The phase shifts are also believed to have something to do with the production of the c-FOS gene. The project was discussed and explained in depth by the mentor. The experiences and observations dealing with this project were interesting and helpful in presenting an overall picture of what is being undertaken in the laboratory.

Another interesting experience this summer was that of learning what was going on in other areas of the laboratory. One of these areas was that of electrophysiology, which was studying nerve impulses in the hypothalamus of the brain, primarily the specific location in which the suprachiasmatic nuclei (SCN) is found. The SCN is the control center for the circadian pacemaker. The way the electrophysiology experiment worked was that a thin slice of a brain form a rat was cut. The slice contained the SCN, which was stimulated using a probe. The nerves, upon being stimulated, would immediately send out signals to other areas of the brain. These signals, and the biochemical substances released by the nerves, were intensely studied. The signals were picked up by an electrode with an extremely fine point and filled with a saline solution. The researcher was able to learn how to prepare these electrodes for the experiment as well as observe the recordings of the nerve impulses. This was one of the most exciting activities going on in the laboratory.

A different area of study was that of the biochemicalseins given off by the nerves in the electrophysiology experiment. The study was performed using a high-performance liquid chromatograph (HPLC). The HPLC took readings of the substances which were collected in the electrophysiology experiment. The researcher was able to observe this procedure and gather information about what proteins and amino acids are directly related to the expression of the c-FOS gene.

At Brooks Air Force Base, on which the laboratory was located, several lectures were presented during the time the researcher was working there. These lectures dealt with many different areas of scientific study and were informative both in the subjects being discussed and in the way scientific reports should be organized and presented.

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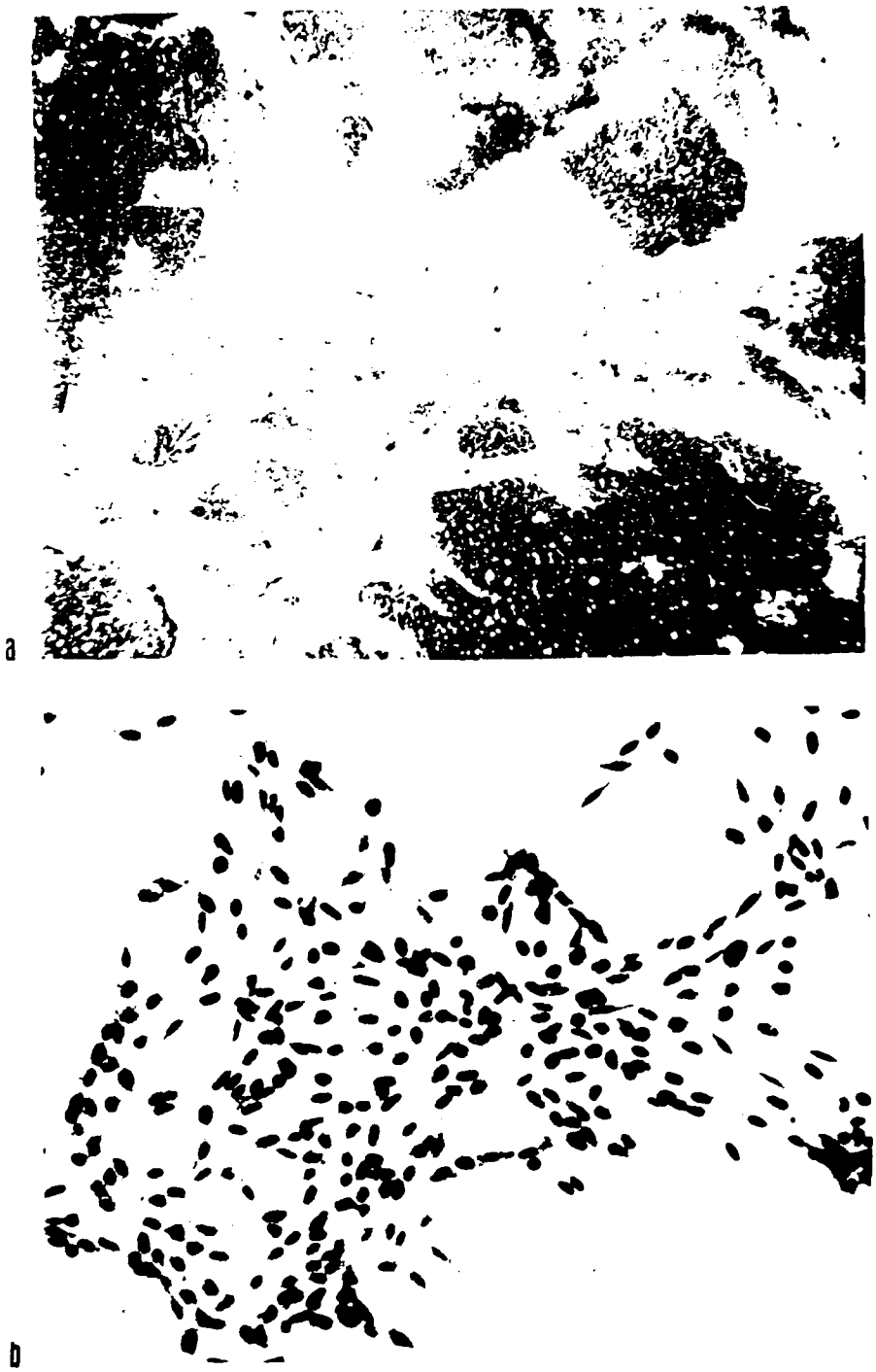

Figure 1: NIH 3T3 cells photographed under (a) darkfield microscopy and (b) brightfield microscopy. Note c-fos immunoreactive cell nuclei (b).

Figure 2: Autoradiogram of c-fos proteins determined by PAGE and Western Blot analysis. (a) Molecular weight standards, (b) 3T3 cell nuclear proteins after fos antiserum, (c) 3T3 cell nuclear proteins after inactivated (preabsorbed) fos antiserum. Note the loss of the 45 Kd band (*) indicating that this band is a fos protein.

Biological Rhythms Research

Lori Olenick

Brooks AFB, TX

Summer 1990

In partial fulfillment of the UES

Summer Student Requirements

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INTRODUCTION:

Determining the best work environmental conditions is essential to increasing worker performance and comfort. Military personnel must be ready to move at a moment's notice, but working irregular shifts and missing sleep may have dangerous consequences if the body's normal rhythmicity is impaired. The same holds true for shift workers just starting a new shift and travelers who must cross several time zones. The human body has an endogenous "clock" that, in a sense, must be "reset" before an individual whose biological rhythms are distorted can once again perform at his or her best.

Studies conducted at the United States Air Force School of Aerospace Medicine last summer and this past summer address the problem of fatigue caused by disrupting biological rhythms. Specifically, the researchers are studying the effects of broad spectrum illumination on the production of the hormone melatonin and the resulting effects on fatigue.

BACKGROUND:

The human circadian cycle, or biological clock, runs on about a 25 hour schedule. The production of hormones, heart rate, and body temperature all depend on the body clock as do blood pressure,

performance, and mental alertness.

The hormone melatonin, produced by the pineal gland near the brain stem, depends upon and may even drive other circadian rhythms. Many studies suggest that melatonin acts as an endogenous sleep promoting compound during the sleep phase of the circadian rest cycle. The production of melatonin is adjusted by the days and nights of the outside world because of the pineal glands sensitivity to ambient light. Melatonin is manufactured steadily throughout the night beginning at dusk and dropping off by dawn although plasma levels are approximately ten times greater at night.

Studies also suggest that melatonin has a depressant effect upon arousal, attention, and motor activity in animals. Melatonin suppression by bright (>3000 lux) light is key to the studies conducted at the School of Aerospace Medicine because its suppression may allow for less fatigue hence enhanced performance.

Findings from the study conducted in 1989 suggest that broad spectra, bright light does suppress the production of melatonin. Body temperature is an important non-invasive method to measure the physiological response to fatigue caused by extended time awake. Normally, the core body temperature is lowest during the middle of the night. Data from these studies suggest that the average body temperature of the bright light treated group was significantly different from the dim light group at three key time points: 2130,

0130, and 0330 hrs (Figure 1).

PROCEDURE:

The two summer studies were parallel and shared many similarities, but the study currently underway addresses some questions that resulted from the initial study. One concern was what would happen if the subjects remained awake even longer than 30 hours. To answer this, the investigators have increased the study duration to 36 hours. Other new factors are 1) to include female as well as male subjects to determine how the light treatment affects female circadian physiology and performance and compare between the sexes, 2) to include auditory and physical measures as well as the visual measures taken in the previous study, 3) to vary workload (high vs. low) on the computer tests to determine if workload tasks are influenced by fatigue.

The subjects were divided into two groups. They arrived at the lab at 0700 and were prepared for EEG and EOG measurements that were taken every two hours. The subjects were seated in five seperate, sound attenuated booths containing a wide spectrum flourescent illumination sourced and a PC workstation. The lights were adjusted according to the subject's height as well as the treatment condition. Under the "dim" condition, the subjects sat beneath a light providing approximately 100 lux illumance, which was measured from the subject's eye level. The bright condition

provided the subject with approximately 3200 lux. These lux levels fall within the recommended range of 50 to 3230 lux which is authorized for military environments. It should be noted that these levels are not excessive. An individual would receive about 10,000 lux of illumination outside on a cloudy day. Subjects were advised to refrain from taking all drugs and staying out of direct sunlight for 72 hours prior to the beginning of the study.

Subjects in the both studies took a battery of computer role playing tasks, including the Walter Reed Performance Assessment Battery (WRPAB), the Complex Cognitive Battery (CCAB), and the Naval Aerospace Medical Research Institute Battery (NMRI). These tests measured the subjects' reaction time and reasoning skills. Several new tests were added to the new test battery. These included the dichotic listening task (DLT) and physical stressors, including gripping a dynonometer and holding a weight with an extended arm as long as possible. The purpose of the weight and dynonometer tasks was to determine if light treatment has any affect on physical stressors in addition to its apparent affects on mental and physiological stressors.

Workload tasks are varied throughout the study (either high or low workload). They are presented in a manner such that the same number of high and low workload tasks will be given in an alternating manner throughout the 12 performance trials. Workload tasks will be an attempt to measure the effects of light on

increased cognitive and physical workload and will consist of either an increase in the amount or in the dutation of the conditions involved.

The new study is ongoing and will not be finished for a few months. However, performance data from the 1989 study is included to demonstrate the results that are expected. Figure 2 shows the results of one of the accuracy variables and Figure 3, the results from one of the response time variables. These figures show that the addition of bright light in the early morning hours improved accuracy and reaction time on these and other tests probably by the suppression of melatonin.

Rail Garrison Sleep Actigraph Data:

The quality of rest during the sleep phase of the Rail Garrison subjects was measured with the use of wrist activity monitors. Actigraps were supplied by the Walter Reed Army Research Institute. These wrist worn monitors register the number of movements per minute through a piezoelectric crystal sensitive to movement in a 3 dimensional space. Therefore, the monitors may be used as a measure of restfullness in sleep by showing the amount of movement that the wrist makes during sleep.

The Rail Garrison project attempted to determine the quality of sleep and performance in soldiers operating a missle launcher from a railroad car. The subjects in the Rail Garrison study were

orgainzed into two main groups: nocturnal (night) sleepers and diurnal (day) sleepers. The sleep period for the nocturnal sleepers was from midnight to noon, and for diurnal sleepers it was from noon to midnight. These groups were further divided by call letter--launch car operators were "limas", security personnel were "sierras", and persons responsible for maintenence were "mikes".

The data from the activity monitors were first arranged so that each subject's data were seperated into "wake" and "sleep" periods. Then the data were visually inspected during the sleep periods and rated according to the number of spikes which indicated many movements per minute (lots of activity) or lowpoints, indicating restfullness (little activity).

The ratings for all subjects in one group were averaged across time: for instance, the average of all "limas" for 0200 was taken. Using this data enabled a comparison for restfullness between groups (Figure 4). Essentially no differences were found for any of the groups. These an other data are taken to mean that soldiers can operate a missle launcher from a railroad car for at least 30 days with no performance decrements or sleep problems.

ACTIVITY BY WEEK:

June 18-22:
--Literature Search Techniques in Strughold Library (use of CD ROMS; keywords: printers, search software) Example: circadian rhythms, light and memoty effects in Medline.

--Readings: papers and related lab reports

--Entered POMS data from light study into computer using French POMS Analytical Program

--Organized POMS data files with word processor into SAS compatible form.

--Descriptive statistics and graphs for POMS data on a spreadsheet (Lotus 1-2-3)

--Lectures and luncheons for UES summer curriculum.

--Participated as subject in research experiment (Drs. Britemeyer and Weinstein; 3-D perception)

June 25-29:
--Statistical analysis on POMS data

--Actigraph data on Rail Garrison cut and and made into strips

--Attend weekly UES seminar

--Literature search assignment on circadian or biological rhythms and memory or performance, temazepam. Review all abstracts found and select most relevant. At least 5 important articles found.

--Participated as subject (3-D experiment)

July 2-6:
--Actigraph data ranked and entered in spresdsheet form for prelimanary graphy (prior to any statistical analysis if necessary)

--Literature search: mathematical models of circadian rhythms. Nakao, Borbely (author search, not subject search)

--Attend weekly seminar

--Participated as subject (3-D experiment)

July 9-13:
--EEG data analysis for Light Study graphs

--Sleep surveys scored from light study

July 16-20:
--EEG data for Light Study graphs

--NMRI data organized

--Notches on EEG data for light study

July 23-27:
--Inventory supplies light study

--Notches on EEG data for Temazepam study

--NMRI data into spreadsheets, graphed, put into SAS

--Attend weekly seminar

--Rail Garrison strips organized, stored

July 30-Aug 3:
--Prepare subject sequence manual for upcoming study

--Help set up for upcoming study

--Clean and organize office space

--Attend weekly seminar

--Contact subjects

Aug 5-Aug 10:
--Merge NMRI files

--Prepare supply list for re-orders

--Subject lists and requirements

--Help set up for upcoming students

FIGURE 1

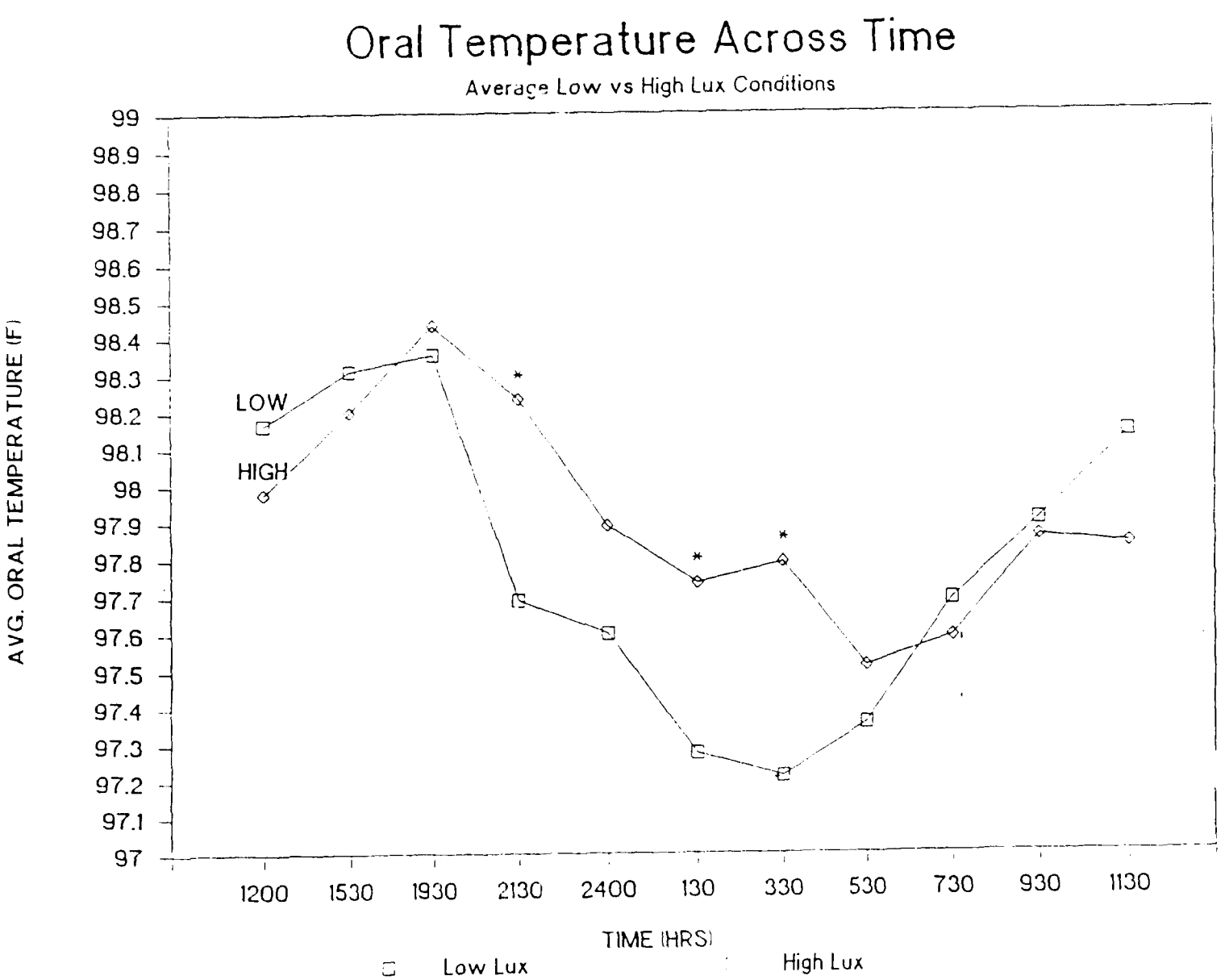

Oral Temperature Across Time
Average Low vs High Lux Conditions
AVG. ORAL TEMPERATURE (F)
99
98.9
98.8
98.7
98.6
98.5
98.4
98.3
98.2
98.1
98
97.9
97.8
97.7
97.6
97.5
97.4
97.3
97.2
97.1
97
LOW
HIGH
1200
1530
1930
2130
2400
130
330
530
730
930
1130
TIME (HRS)
Low Lux
High Lux

FIGURE 2

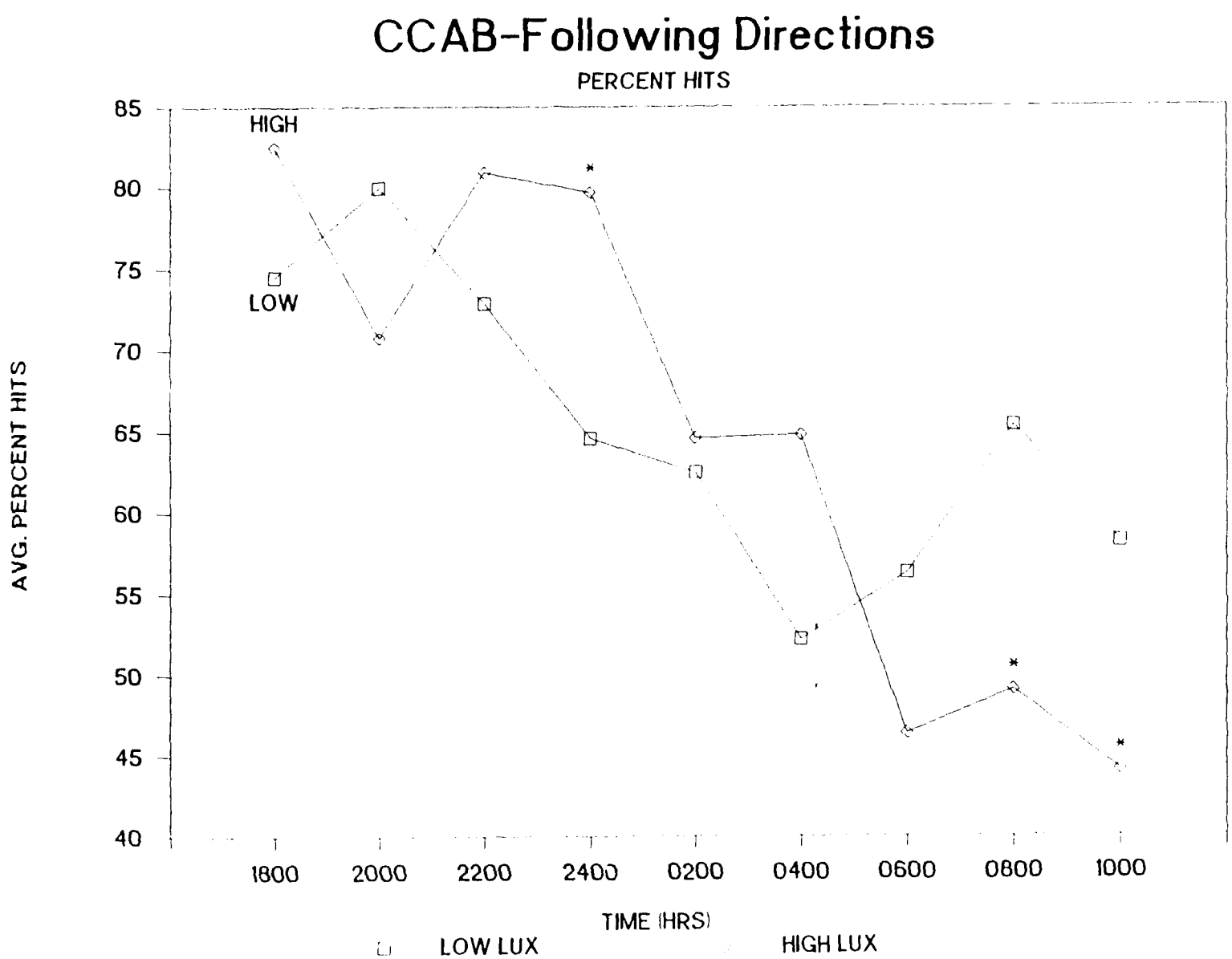

CCAB-Following Directions
PERCENT HITS
HIGH
LOW
85
80
75
70
65
60
55
50
45
40
AVG. PERCENT HITS
1800
2000
2200
2400
0200
0400
0600
0800
1000
TIME (HRS)
LOW LUX
HIGH LUX

FIGURE 3

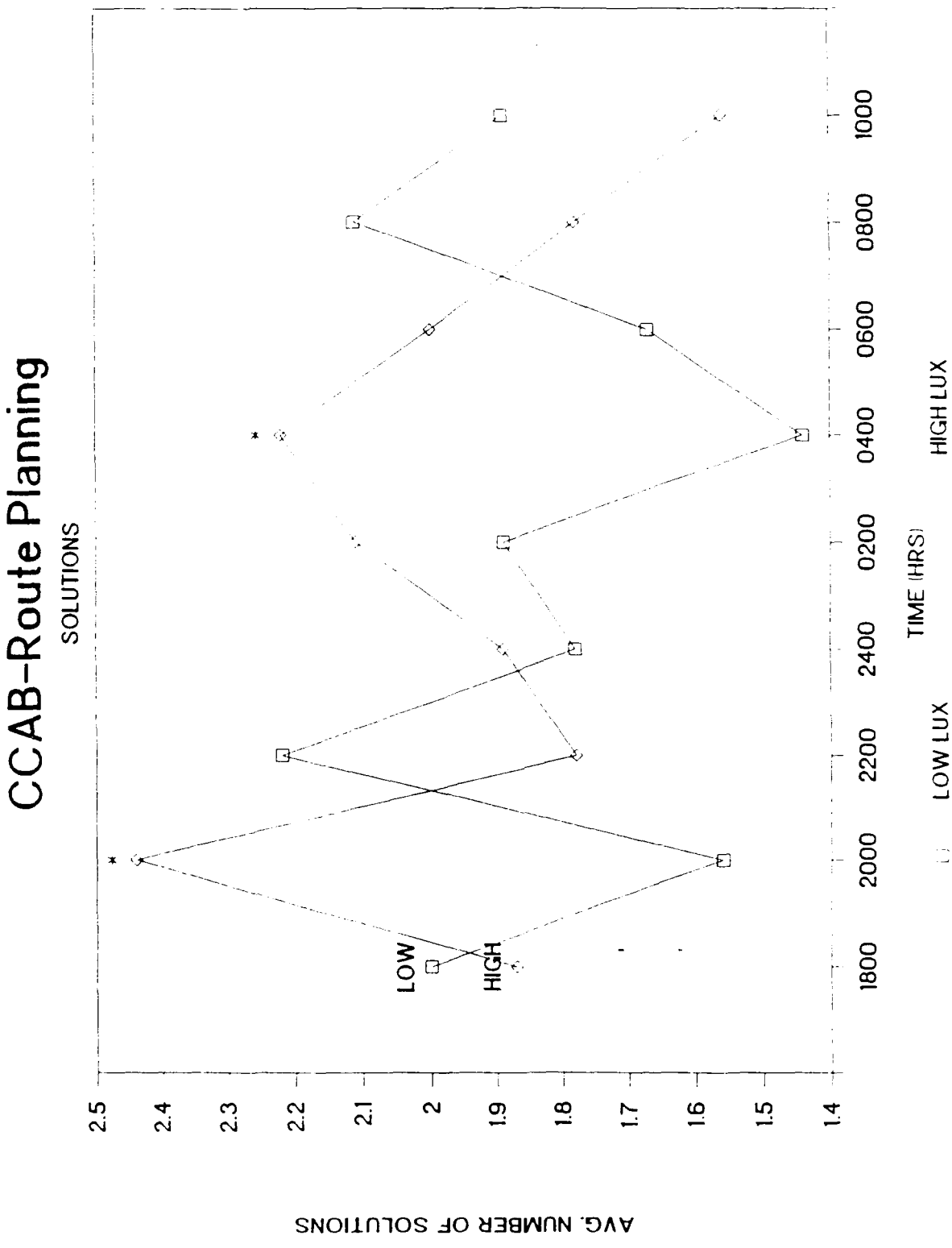

CCAB-Route Planning
SOLUTIONS
AVG. NUMBER OF SOLUTIONS
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
LOW
HIGH
1800
2000
2200
2400
0200
0400
0600
0800
1000
TIME (HRS)
LOW LUX
HIGH LUX

FIGURE 4

RAIL-GARRISON STUDY

AVERAGE SLEEP RATINGS FOR LIMAS

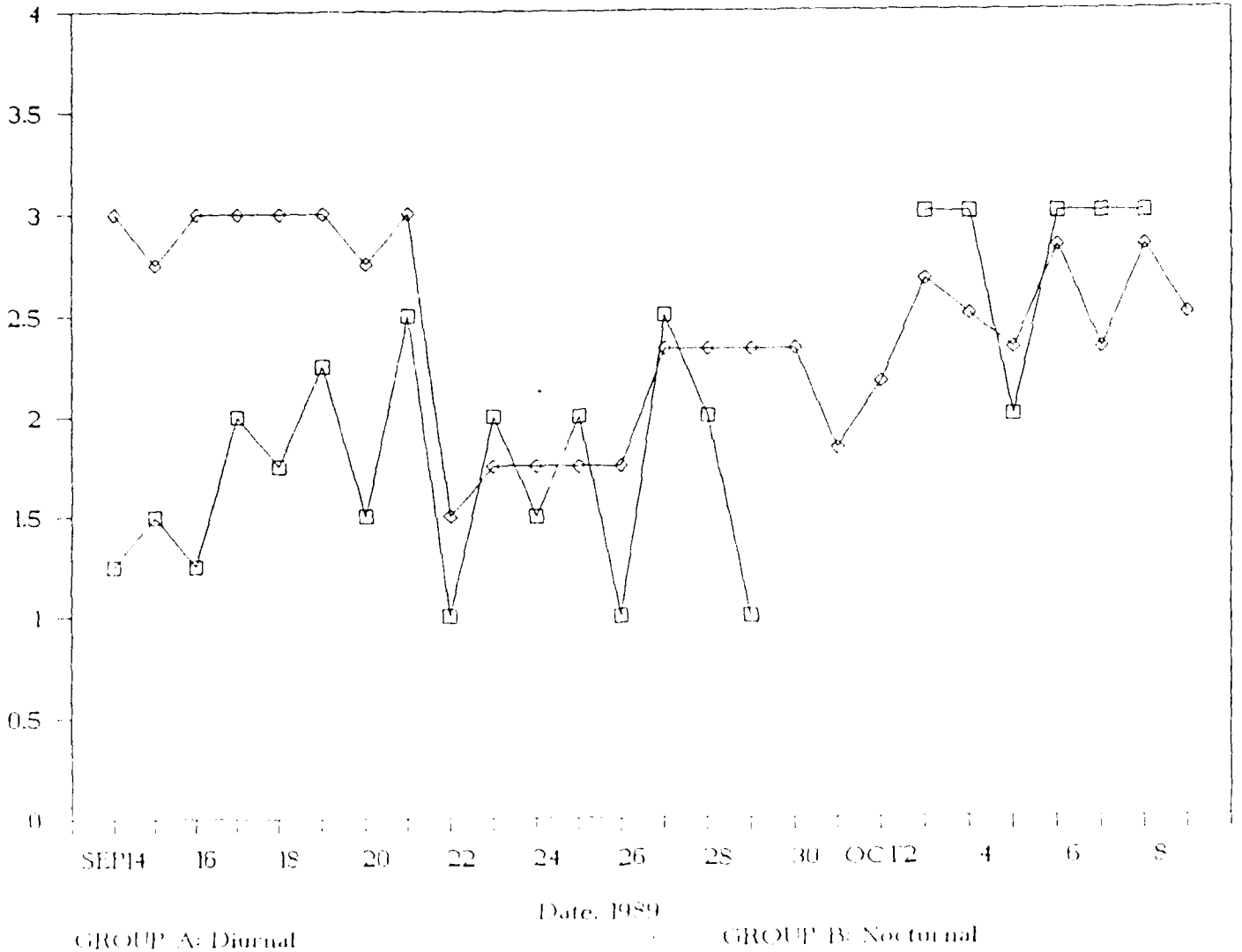


FIGURE 6

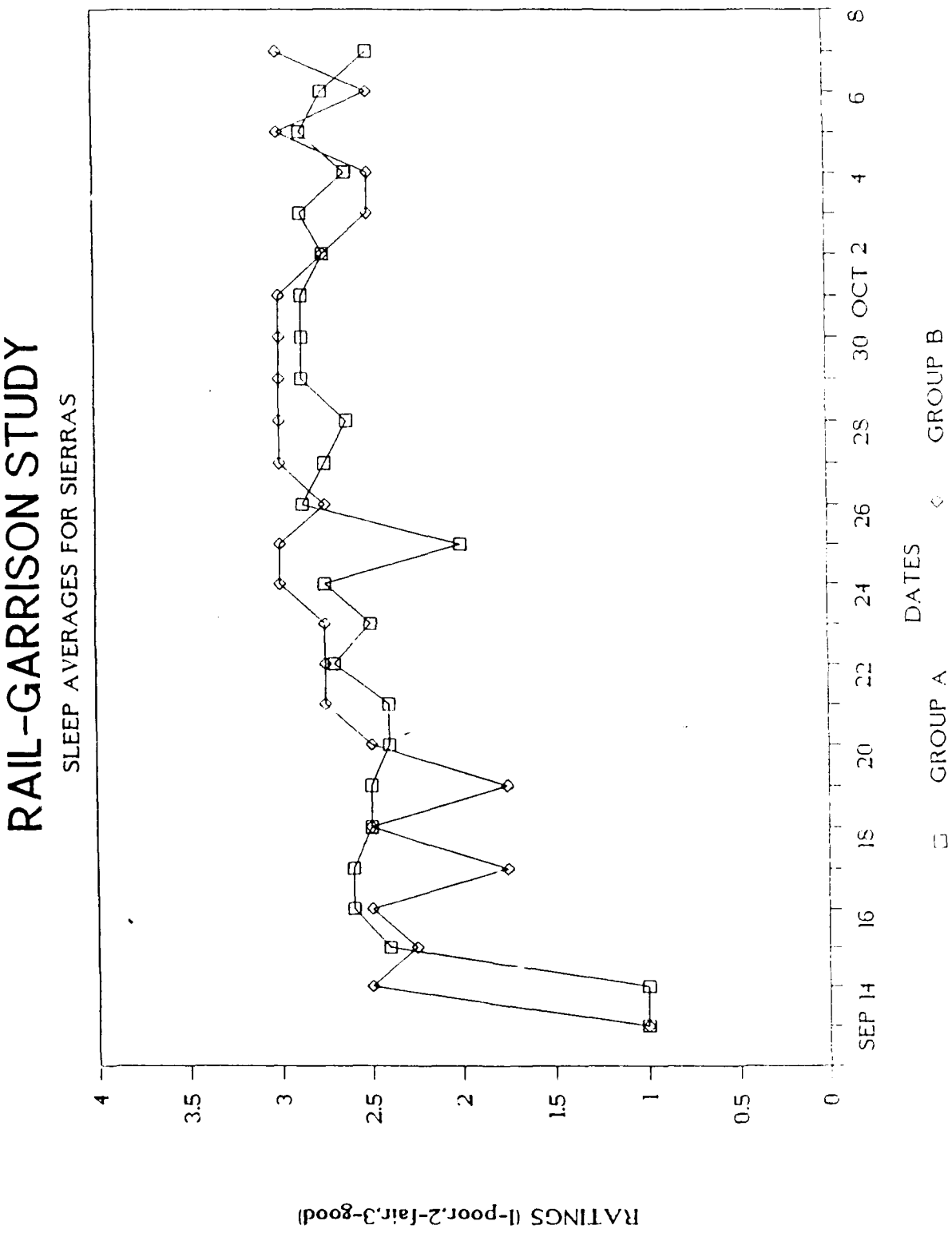

RAIL-GARRISON STUDY
SLEEP AVERAGES FOR SIERRAS
RATINGS (1-poor,2-fair,3-good)
4
3.5
3
2.5
2
1.5
1
0.5
0
SEP 14
16
18
20
22
24
26
28
30
OCT 2
4
6
8
DATES
GROUP A
GROUP B

FIGURE 5

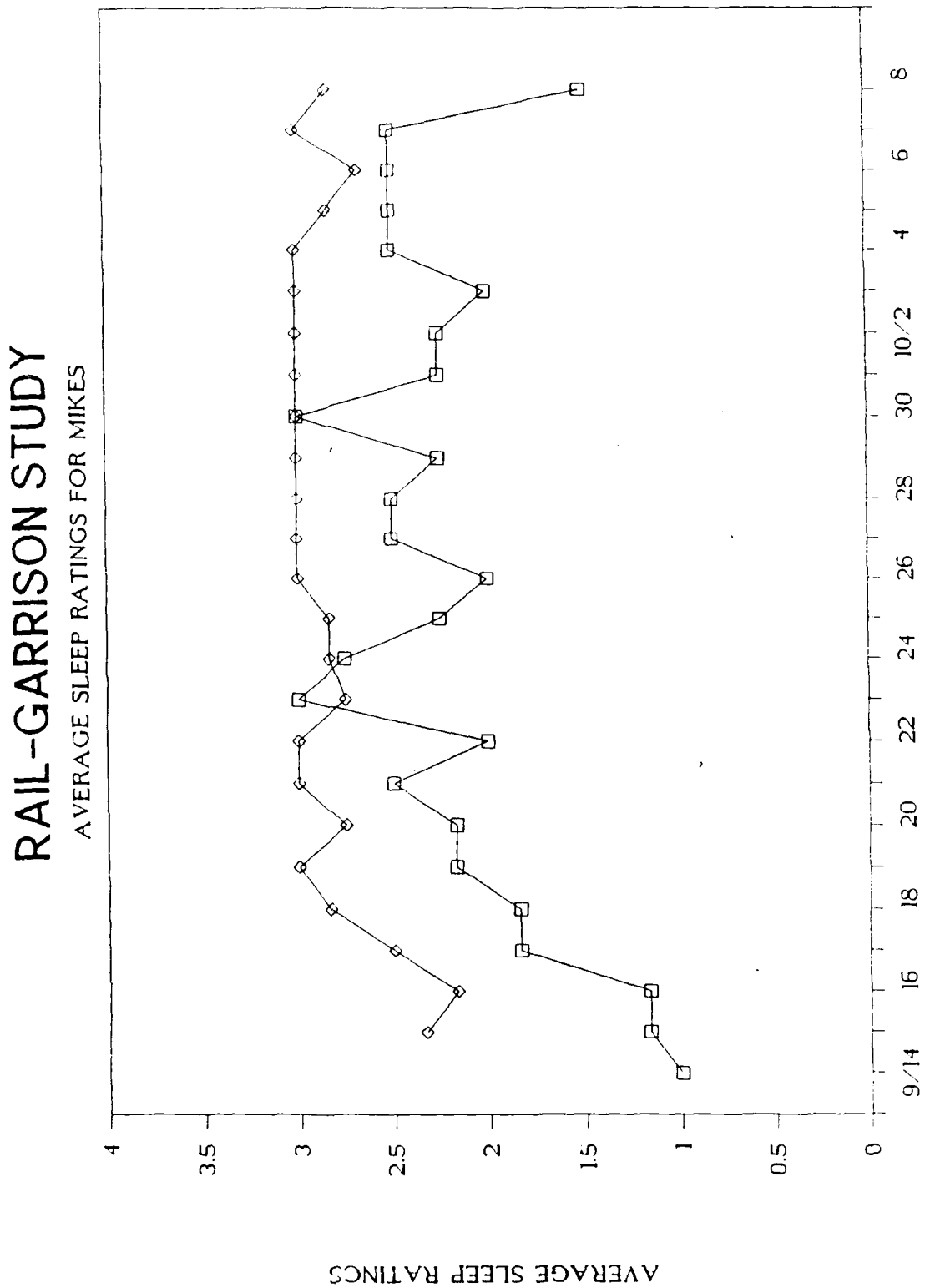
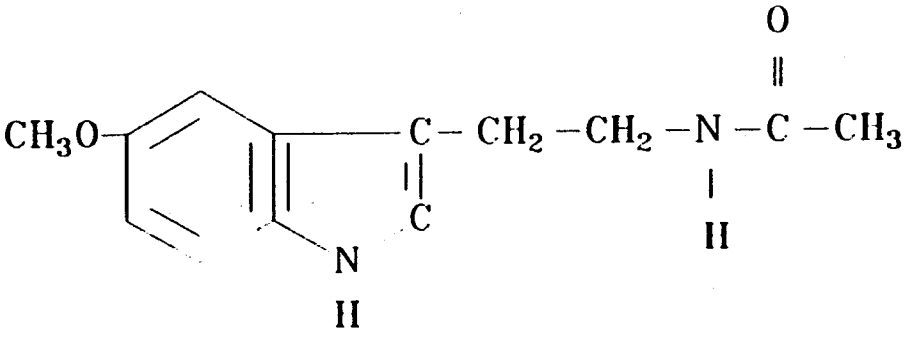

RAIL-GARRISON STUDY
AVERAGE SLEEP RATINGS FOR MIKES
AVERAGE SLEEP RATINGS
4
3.5
3
2.5
2
1.5
1
0.5
0
9/14
16
18
20
22
24
26
28
30
10/2
4
6
8
GROUP A
GROUP B

FIGURE 7



MELATONIN ($C_{13}H_{16}N_2O_2$)

(N–Acetyl–Methoxyserotonin)

Joanna Saucedo

Final Report Number 119

Report on File with UES and SAM

HIGH SCHOOL APPRENTICESHIP PROGRAM

FINAL REPORT

STUDENT: WENDY SHIELDS

MENTOR: LT COL PINKOVSKY

TITLE: MEDICAL ENTOMOLOGY ACTIVITIES

DATE: AUGUST 10, 1990

I sincerely thank the following individuals for their encouragement, suggestions, and sharing of knowledge and experience:

Lt Col Dennis D. Pinkovsky

Capt Terry L. Carpenter

Capt David E. Bowles

1Lt Sharon L. Spradling

Dr Chad P. McHugh

SrA Paul A. Hanny

Janina D. Casias

GENERAL DESCRIPTION OF ACTIVITIES

Introduction

My work at the Epidemiology Division of Brooks AFB began on June 18, 1990. I met my mentor, Lt Col Dennis D. Pinkovsky, at the US Air Force School of Aerospace Medicine. He introduced me to several people with whom I would be working. I was given a list of projects on which I could or would be working. Through my eight weeks I touched on them all and became more deeply involved with some.

A few projects which were just 'touched' upon included assisting Capt Carpenter on his project with ultraviolet fly traps at Kelly AFB and assisting Dr McHugh with fluorescent antibody tests for parasitic material in collected rat specimens. With Capt Bowles I have applied Cythion® insecticide to Aedes albopictus mosquitoes using topical application. I also have aided Capt Bowles with feedings and management of his fly and mosquito colonies. 1Lt Spradling started a new project recently with my help. She and I surveyed the Brooks AFB medical clinic for ants. We wanted to see what kind and how many ants were present. I did most of my work with SrA Hanny. He taught me how to use the various computers for data entry and analysis of mosquito and ovipaddle identification information. I also learned how to pin and label mosquitoes for display collections. The most important project I handled was ovi paddle set up and identification; both Dr McHugh and SrA Hanny aided me. I will concentrate my report on this.

Detailed Description of Activities

Much of my medical entomology efforts dealt with egg deposition paddles (ovipaddles) from mosquito oviposition jar traps (ovitraps) and the rearing of larvae and adult mosquitoes from mosquito eggs which were present on the ovipaddles. Three main species of mosquitoes which develop as immatures in artificial and natural water containers like to lay eggs on ovipaddles. A black plastic jar or cup (fig.1) partially filled with water, is used for an ovitrap because, the mosquitoes are attracted, due to color, humidity, etc., to such water containers to deposit their eggs. First, ovipaddles were made using wooden tongue depressors, brown paper towels and a stapler. The paper towel is cut into four smaller sections and then is wrapped around each tongue depressor and stapled (fig. 1). I avoided many folds or too much thick, loose paper. A rock (to keep the cup from blowing over), a little water, and one or two ovipaddles, affixed vertically to the side with a paper clip, are placed in the black cup. The cups (ovitraps) are taken to preplanned collection sites and positioned in shady spots. Sites are chosen away from areas where rain water may flood the jars. Since black, discarded tires are competing sites where mosquitoes may lay their eggs, ovitrap locations are chosen away from tires.

In about a week, each cup is visited and each ovipaddle is removed and put in a plastic baggie. (Each cup is washed out with water and new ovipaddles are positioned.) Each bag is marked with collection site number, collection date, and the collector's name. The ovipaddles are brought back to the laboratory to see if any are positive for mosquito eggs. Unless there are several hundred eggs, you will need to use a dissecting microscope to confirm the presence of eggs. As stated be-

fore, there are three primary mosquito species (Aedes albopictus, Aedes aegypti, or Aedes triseriatus), which might deposit eggs in the ovi-traps. When you look at the eggs there will be only two categories that you can identify them as: Aedes triseriatus (fig.2) or Aedes (Stegomyia) spp. It is not possible to separate Aedes aegypti (fig. 3) and Aedes albopictus (fig. 4) from only the appearance of the eggs. After you rear out the eggs, then, you can separate the Aedes (Stegomyia) spp into Aedes albopictus and Aedes aegypti groups.

The mosquito rearing takes longer than the actual collection. After you see that the paddles are ovipositive, they are cut up and put in a petri dish marked with the same collection data. The petri dishes are put in an environmental chamber. This will "condition" the eggs in a nice humid atmosphere and increase their likelihood of hatching. In about four or five days the paddles are flooded. Deoxygenated warm water is placed in specimen cups and the paddle pieces are dropped in each. Add a few drops of liver food to each. Collection data is written on the cups and a clear plastic cover is put over the cups. This needs to be done in case the eggs hatch, mosquitoes develop to adults, and begin emerging, (and escaping)!! The eggs will hatch and first produce aquatic stages known as larvae or "wrigglers" which then, in about a week become "tumblers" or pupae, and finally transform into the adult male or female mosquitoes. After pupae appear, the specimen cups are placed in adult emergence cages. We use ice cream tubs with cloth/screen mesh over the top. The mosquitoes will emerge at different rates. You can wait until they all emerge or when you just see some, to identify them. To immobilize the adults to identify them, you will need to use CO_2 to knock them out, or you can freeze them.

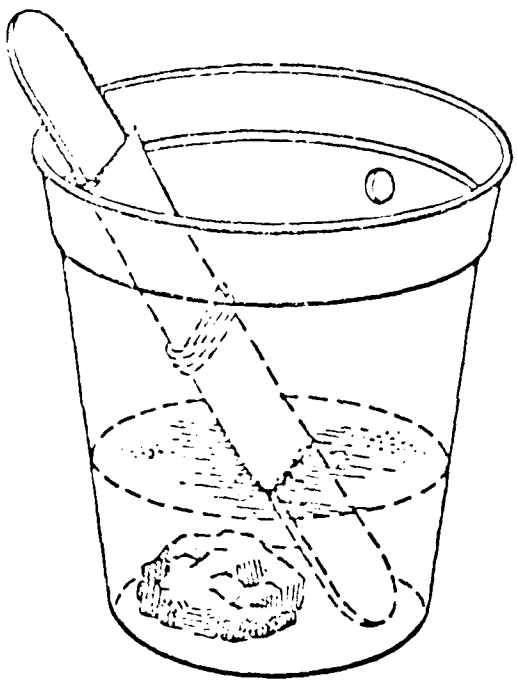


Fig. 1. Ovitrap jar with ovipaddle.

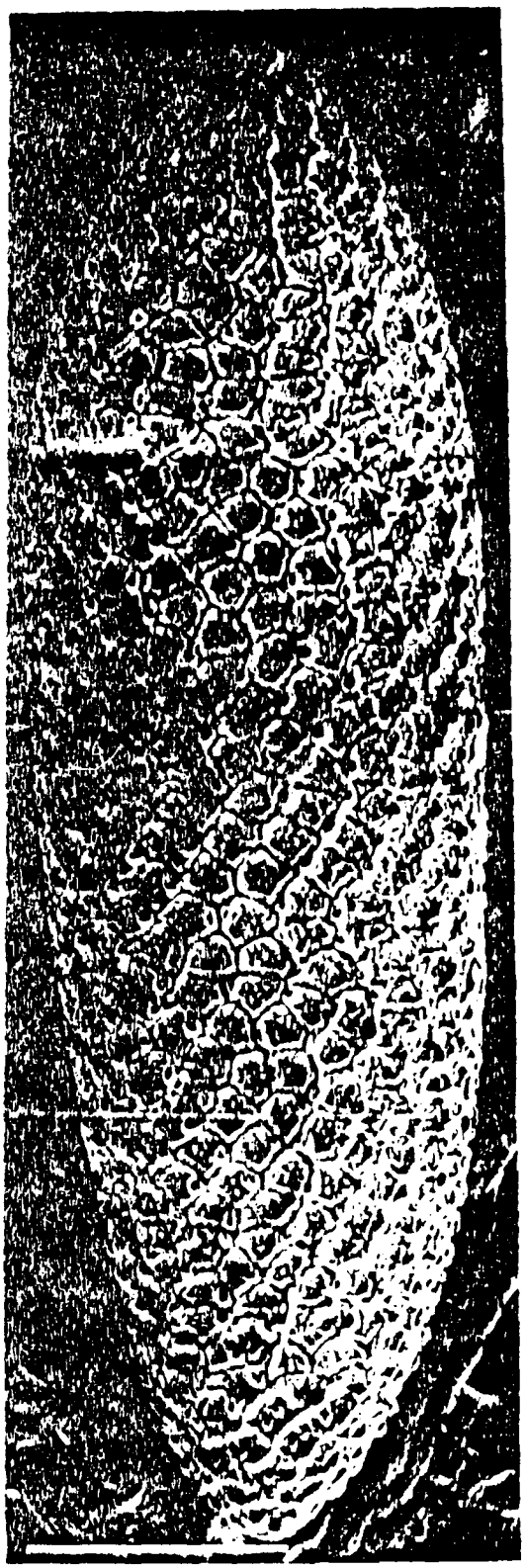


Fig. 2. Aedes triseriatus.

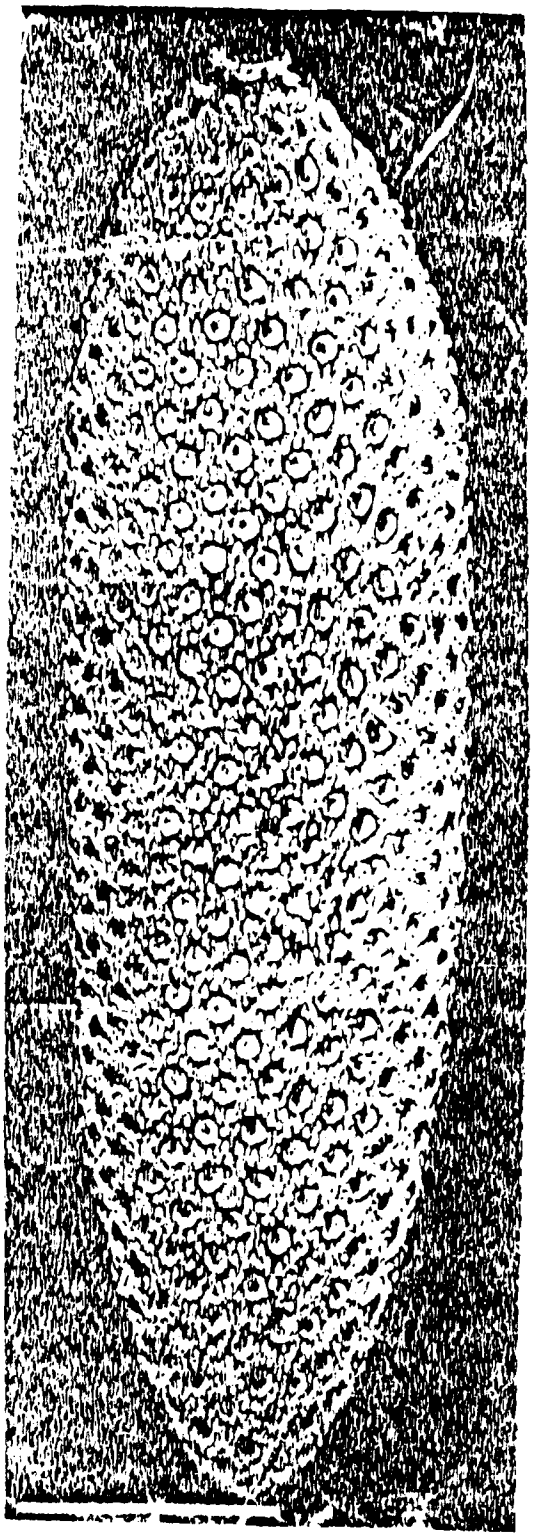


Fig. 3. Aedes aegypti.

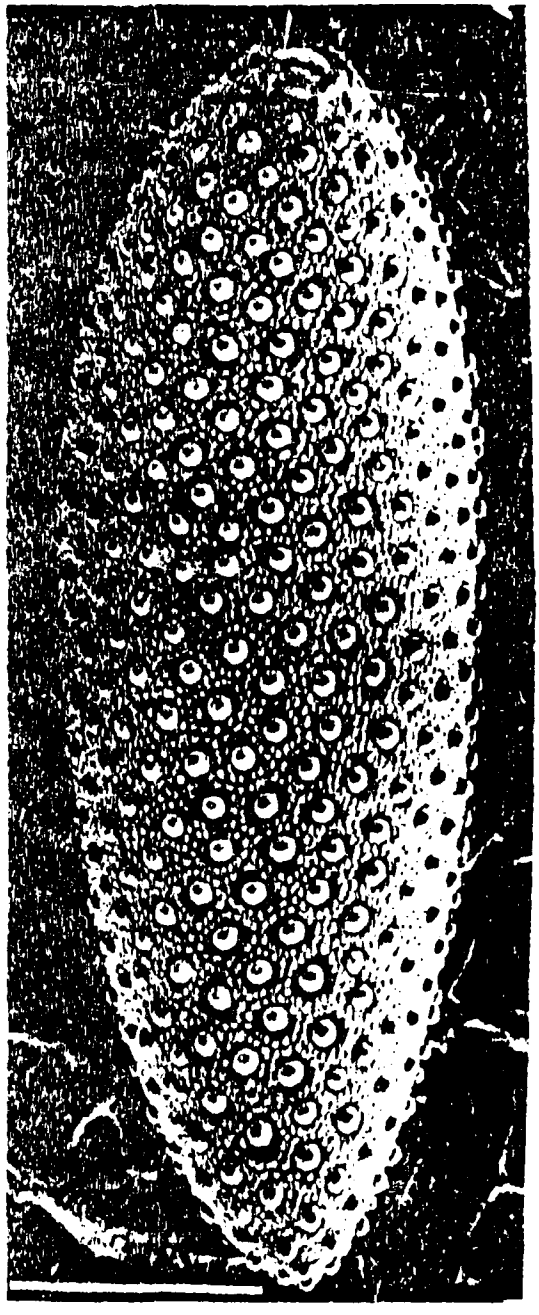


Fig. 4. Aedes albopictus.

Results:

Dr McHugh and SrA Hanny aided me with the ovipaddle identification and rearing. Together we looked at 820 ovipaddles, of which, 95 were ovipositive. Eggs from 85 of the 95 ovipaddles hatched through our rearing efforts. The ovipaddles were sent to our Medical Entomology Section for identification from 50 different Air Force bases. Several bases sent in regular shipments each week.

We raised Aedes albopictus, Aedes aegypti, and Aedes triseriatus. After they were reared we identified which Aedes spp they were. We identified from rearing 180 Aedes albopictus, 150 Aedes aegypti, 185 Aedes triseriatus. Reports of our identification findings were sent back to each of the specimen submitting bases.

Other interesting observations and lessons learned from summer experience:

I enjoyed my stay at the Entomology Section this summer. I learned a great deal. When I was first assigned to the section I had never heard of it. I looked it up, it sounded very interesting. Through my work, I have found it very fascinating.

I am very grateful to all who headed up this program. I was allowed to be exposed to real office life, not like anything I would have gotten from a fast food restaurant. I thank everyone involved in my experience.

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Darsie, Richard F. Jr. and Ronald A. Ward. 1981, Utah Pub. by American Mosquito Control Association 313 pgs. Identification and Georgraphical Distribution of the Mosquitoes of North America, North of Mexico.

Mosquito Surveillance, Biology and Control, Epidemiology Division, USAF School of Aerospace Medicine, Human Systems Division (AFSC), Brooks AFB TX.

High School Apprentice: Brent D. Strawn

Mentors: B. Jon Klauenberg, Ph.D.

John M. Ziriax, Ph.D.

ESTABLISHING HIGH AND LOW RATE OPERANT BEHAVIOR IN RATS

17 Aug 1990

ACKNOWLEDGEMENTS

I would like to thank Drs Jon Klauenberg and John Ziriax for their time, instruction and for providing the opportunity to experience behavioral psychology in the laboratory. I would like to thank Staff Sergeant Stan Carter for his helpful advice on SKED programming.

I: INTRODUCTION

High power microwave (HPM) generators capable of producing extremely high peak power pulses have been developed recently. Current occupational safety standards for radiofrequency exposure are based on the average power density of irradiation and may lack applicability in situations where peak power density is quite high while average power is relatively low.

Behavioral measures are among the most sensitive indices of biological effects (Elder and Cahill, 1984). Disruption of ongoing behavior is the most commonly reported effect in the literature (Justesen and King, 1970). Alterations in behavior are frequently the first indication that a biologically significant event has occurred.

Klauenberg et al. (1988ab) has reported that high power microwave irradiation may produce startle responses and disrupt performance of a rotarod task in rats.

The rate at which behaviors are emitted has been shown to be a factor in the behavioral response to various treatments. Dews and Wenger (1977) reported that the effect of amphetamine is inversely related to baseline rate of behavior; the higher rate of behaviors were decreased and

the lower rate behaviors were increased. D'Andrea and Cobb (1987) using Long-Evans rats trained to perform a time related observing task reported that exposure in a wave guide significant reduction in response rates and significant increases in reaction times at peak powers of 496.7 and 336.7 kW but not 146.7 kW. Wachtel and his colleagues (Wachtel et al., 1988a, b) reported that microwave irradiation of mice caused behavioral effects ranging from induced reflexive movements to decreased locomotor activity to death depending on the number of pulses delivered. Thomas et al. (1975) reported that 30 min exposure to low level pulsed and continuous microwave fields had a rate dependent effect on Sprague Dawley rats. However, Akyel et al. (1988) failed to find any rate dependent effects of high peak power microwave exposure when rats were tested 13 min after exposure. The effects of concurrent high power microwave exposures on ongoing behaviors of different rates has not received adequate attention.

This project will compare the effects of concurrent high peak power microwave irradiation on rats performing high rate behaviors to rats performing at low rates. Initially, computer program schedules will be developed and rats will be trained to perform at either a high or low rate.

II: METHOD

Subjects and Apparatus:

Two male Sprague-Dawley rats (average weight, 460g) were trained in a standard modular test cage (Coulbourn Instruments, Incorporated, Lehigh Valley, Pennsylvania). The chamber consisted of 3 operant response levers. The right and left levers were located 8.5 centimeters above the operant cage floor and the center lever was directly over the feeder access between the left and right lever. Three stimulus cue lights (red, yellow, green) were located directly over the operant lever. The speaker was 8 centimeters above the left cue lights. The houselight was located 2 cm below the operant cage edge. Food reinforcement consisted of 45 mg sucrose pellets (Bio Serv, Frenchtown, New Jersey).

The activity monitoring chamber consisted of a Coulbourn operant chamber placed on a photo beam holder plate consisting of 4 photo beam cells. Two photo cells were placed adjacent to the left and right walls while the third one was located 4 cm from the far left wall and the fourth was located 8 cm from the far left wall.

Both chambers were connected to a Digital PDP-11 computer system using SKED-11 software (Snapper et al., 1972) and hardware by State Systems (State Systems, Incorporated, Kalamazoo, Michigan).

Procedure:

To obtain preliminary data on effects of radiofrequency radiation on different rates of behavior, two rats were trained on schedules that produced either a high or low response rate. A low rate of behavior was generated by programming the operant chamber to deliver a pellet on a differential reinforcement of low rate of response (DRL) schedule (appendix A and B). In this case, the rat was required to withhold responding for a 7 second period after each reinforcement. A high rate of responding was generated by a fixed ratio 7 (FR7) schedule (see appendix C and D). In this case the rat must respond 7 times before receiving a reward. The faster the rat presses the lever the faster the reward is obtained.

Shaping:

Each rat was placed in the activity box for ten minutes before and after each daily session in the operant chamber. The activity box recorded the amount of activity

in the chamber using a SKED-11 program (see appendix E and F). Before shaping, the rats were gradually food deprived to 80% of their free feed body weight. When the rats were first placed in the operant chamber, there were 30 to 40 pellets of food in the pellet cup so the rats would become accustomed to eating from the food cup. After 4 days of free food, a program was instituted in which every 30 seconds a pellet was dropped, the houselight turned off and the pellet light was turned on concurrent with the dropping pellet.

A string was attached to the back of the lever to give the experimenter control over the delivery of reinforcements during the process of successive approximation. When the rat would go over to the general area by the lever, the string was pulled, delivering a pellet, turning on the food access light, and turning off the houselight. As the session continued the rat was required to position itself closer and closer to the lever to get a reinforcement. Each time he received a pellet the lights would go off and the food cup light would go on producing conditionable stimuli. This reinforced the association of food delivery into the food cup. To insure continued deprivation, a 110 reinforcement limit was added to all shaping schedules. Rat number one was initially placed on a drl 1 second schedule which was increased by 1

second every two days. Rat number two was initially placed on a continuous reinforcement (FR1) and every two days was required to respond once more for a reward.

III: RESULTS

The timed interval between each consecutive lever press or the interresponse time (IRT) of the two rats last session are graphically illustrated in figure 1. The graphs illustrate the number of IRTs emitted between 0 and 20 seconds in 1 second intervals. IRTs less than seven seconds in figure 1 were not reinforced by the DRL schedule. Only IRTs of 7 seconds or more were reinforced. Rat number 2 was not required to wait to respond. As expected, since rat number 2 was reinforced for a fixed number of responses, responding by this rat was at a much higher rate than that of rat number 1.

IV: REFERENCES

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APPENDIX A: DRL PROGRAM

```
_HSC002$DUA7:[ZIRIAX]DRL.CMD;1                                  29-AUG-1990 07:50

 enable substitution
 enable global
 enable decimal
 enable quiet
 open #1 ti:
 sets $box "3"
 sets $expid "d"
,'$expid'
 sets $fdir "lb:[200,3]"
 start:
clr
 ;---------------------make SKED date for file names----------------------
 ;find name of sked data file
        .sets $mmm <DATE>[4:6]
 ;'$mmm'
        .sets $da <DATE>[1:2]
 ,'$da'
        .sets $yy <DATE>[8:9]
 ;'$yy'
        .sets $dat $da+$mmm+$yy
        .sets $fdate <date>[1:9]
        .sets $ftime <time>
        .sets $dytim $fdate+" "+$ftime
 ;-----------------------------Is box free-----------------------------------
        .Setf <erseen>
        sk ac/s '$box'
        .if <exstat> = 1 .data#1 Box '$box' is active. TOO BAD FOR YOU!!(chuckle,chuckle,giggle.
        .if <exstat> = 1 .goto stop
 ;-----------------------------Test box--------------------------------------
 ask [<true>] goon Want to run an experiment? (type no to exit)
 iff goon .goto exit
 ;---------------------------Identify Conditions-----------------------------
 setn $wght 0
 sets $stat $box
 ;-------------------------------Subject-------------------------------------
 ,Enter a ZERO for rat id, if you are not running a box.
 askn [0:99] $ratid Box '$box'  Rat id
 if $ratid = 0 .exit
 ;-----------------------------Condition-------------------------------------
 asks [0:70] $cond Box '$box'  Rat # '$ratid' cond
 ;---------------------------Session duration--------------------------------
 askn [0:1440] $sedu How long (in minutes) is this going to take?
 setn $sedu $sedu*6
 ;-----------------------------Drl length------------------------------------
 askn [0:300] $drl What would you like the drl to be in seconds?
 setn $drl $drl*1
 if $drl = 0 .exit
 ;-------------------------------Mass----------------------------------------

 ,enter a mass of 0 if the rat was not weighed

 askn [0:600] $wght Box '$box'  Rat # '$ratid'   Mass
 ;-------------------------create Sked file names----------------------------
        .setn $ids '$ratid'
        sets $wfid $fdir+$expid+$dat+"w "'$ids'"
        .sets $dfil $fdir+$expid+$dat+"d "'$ids'"
        sets $nfid $cond
        sets $nfidv #expid+$dat+"n "+"'$ids'"


 ;-------------------------Load and Modify-----------------------------------
sk lo [user]drl '$box'
 iff <erseen> goto stop
 data #1 modifying station '$box'
        sk m'$box'/s a0 '$ratid'
        sk m'$box'/s a1 $wght
```

```
_HSC002$DUA7:[ZIRIAX]DRL.CMD;1                                  29-AUG-1990 07:50

        sk m'$box'/s d0 '$sedu'000
        sk m'$box'/s c1 '$drl'00
        sk open c '$dfid' '$box'
        sk open n "'$cond'" '$box'
.;------------------------------Start session--------------------------------
.ask [<true>:1200s] $goon start the session?
.iff goon .goto nope
sk st '$box'
.exit
.nope:
.ask [<true>] goon Are you sure?
.iff goon .goto start
sk ab 15 y
.data#1 Oh well, maybe next time.
.exit
.;-----------------------------SKED load error-----------------------------
.stop:
.;
.;ERror in loading state table in station "$box";procedure terminated
.exit
```

```
dim a-37
\0      subject #
\1      subject weight
\2      Tenths of a session completed.
\3      session length in minutes
\4      incorrect responses
\5      correct responses
\6-15   tenths of the time
\16-35  IRT in J(1) units of time
\36     Irt bin size (j(1))
\37     percantage correct

list c-30",30"    \drl length
list d-10',1',1'  \session duration
list j-1",1"      \IRT BIN size
list x-6          \time segment at top

s.s.1:
s1:
        #start:on 3,4,6:set d(1)-d(0)/10,d(2)-d(1),
                a(2)-d(1),a(36)-j(1),j(0)-j(1)--->s2
s2:
        1':add a(3)--->sx
        #r1:add a(x),a(4);z2;set c-c(1)--->sx
        c#t:--->s3
s3:
        #r1:z1;z2;set c-c(1);add a(5),a(x)--->s2

s.s.2:
s10:
        #start: --->s1
s1:
        d(1)#t:set d(1)-d(2);add x,a(2)--->sx          \tenth of session timer
        d(0)#t:type 0,0,!,"finished",!;
               set a(37)- (a(5)*100)/(a(4)+a(5))--->stopcollect
                                                       \end of session timer
        #z1:on 1,2; off 3,4,6--->s2
s2:
        .04":off 1--->s3
s3:
        1.96":off 2;on 3,4,6;
              set a(37)- (a(5)*100)/(a(4)+a(5));
               if a(5)-110 [@done,@cont]--->s1
               @done:type 0,0,!,"he's got his quota",!--->stopcollect
               @cont:--->s1

s.s.3:
s1:
        #z2:set i-0--->s2
s2:
        j#t: set j-j(1);if i<19 [add i]--->sx
        #z2:add a(i+16);set i-0,j-j(1)--->sx
\       #z1:--->s1
```

```
_HSC002$DUA7:[ZIRIAX]LEVER.CMD;1                    29-AUG-1990 07:50

.enable global
.enable substitution
.enable decimal
.enable quiet
.open #1 ti:
.sets $box "J"
.sets $expid "L"
:'$expid'
.sets $fdir "lb:[200,3]"
.start:
clr
.;---------------------make SKED date for file names----------------------
.;find name of sked data file
        .sets $mmm <DATE>[4:6]
.;'$mmm'
        .sets $da <DATE>[1:2]
.;'$da'
        .sets $yy <DATE>[8:9]
.;'$yy'
        .sets $dat $da+$mmm+$yy
        .sets $fdate <date>[1:9]
        .sets $ftime <time>
        .sets $dytim $fdate+" "+$ftime
.;-----------------------------Is box free-----------------------------------
        .Setf <erseen>
        sk ac/s '$box'
        .if <exstat> = 1 .data#1 Box '$box' is active. TOO BAD FOR YOU!!! HAHAHAHAHAHAHAHA!!!!!!
        .if <exstat> = 1 .goto stop
.;-----------------------------Test box--------------------------------------
.ask [<true>] goon Want to run an experiment? (type no to exit)
.iff goon .goto exit
.;---------------------------identify Conditions-----------------------------
.setn $wght 0
.sets $stat $box
.;-----------------------------Subject---------------------------------------
.;Enter a ZERO for rat id, if you are not running a box
.askn [0:99] $ratid Box '$box': Rat id
.if $ratid = 0 .exit
.;-----------------------------Condition-------------------------------------
.asks [0:70] $cond Box '$box': Rat # '$ratid':cond
.;---------------------------session duration-------------------------------
.askn [0:1440] $sedu How long (in minutes) is this going to take?
.setn $sedu $sedu*6
.;-----------------------------Fixed ratio-----------------------------------
.askn [0:10] $fr What is the fixed ratio?
.if $fr = 0 .exit
.;-------------------------------Mass----------------------------------------
.;
.;enter a mass of 0 if the rat was not weighed.
.;
        .askn [0:600] $wght Box '$box': Rat # '$ratid'    Mass
.;-------------------------create Sked file names----------------------------
        .setn $ids '$ratid'
         sets $wfid $fdir+$expid+$dat+"w."+"'$ids'"
         sets $dfid $fdir+$expid+$dat+"o "+"'$ids'"
         sets $nfid $cond
         sets $nfidv #expid+$dat+"n."+"'$ids'"
.;-----------------------------Load and Modify-------------------------------
 sk lo [user]lever '$box'
  if <erseen> .goto stop
  data #1 modifying station '$box'
          sk m'$box'/s a0 '$ratid'
          sk m'$box'/s a1 '$wght'
          sk m'$box'/s d0 '$sedu'000
```

```
_HSC002$DUA7:[ZIRIAX]LEVER.CMD;1                                    29-AUG-1990 07:50

        sk m'$box'/s rl '$fr'
        sk open c '$dfid' '$box'
        sk open n "'$cond'" '$box'
.;------------------------------Start session--------------------------------
.ask [<true>:1200s] $goon start the session?
.iff goon  .goto no
sk st '$box'
.exit
.no:
sk ab 3 y
.exit
.;------------------------------SKED load error------------------------------
.stop:
.;
.;ERROR in loading state table in station "$box', procedure terminated.
.exit
```

APPENDIX D: FR COMMAND FILE

```
_HSC002$DUA7:[ZIRIAX]ACTIVITY.SKD;1                    29-AUG-1990 07:50

dim a-40
\0      subject #
\1      subject weight
\2      session length in minutes
\3      pre & post session data
\4      total counts r1+r2+r3+r4
\5      r1
\6      r2
\7      r3
\8      r4
\9      time
\10-19  tenths of the time
\20-39  IRT in J(1) units of time
\40     IRT bin size (J(1))

list d-10',1',1' \d- time variables
list j-1",1"    \IRT BIN size
list x-10

s.s.1:
s1:
        #r1!#r2!#r3!#r4:set d(1)-d(0)/10,d(2)-d(1),a(9)-d(1),a(40)-j(1),j(0)-j(1)--->s2
s2:
        1':add a(2)--->sx
        d(1)#t:set d(1)-d(2);add x--->sx
        d#t:type 0,0,!,"activity done",!--->s3
                #r1:add a(5),a(4),a(x);z2--->sx
                #r2:add a(6),a(4),a(x);z2--->sx
                #r3:add a(7),a(4),a(x);z2--->sx
                #r4:add a(8),a(4),a(x);z2--->sx

s3:
        5"--->stopcollect

s.s.4.          \IRT distribution
s1:
        #z2:set i-0--->s2
s2
        j#t:set j-j(1);if i<20 [add i]--->sx
        #z2:add a(i+20);set i-0, j-j(1)--->sx
        #z1:--->s1
```

APPENDIX E: ACTIVITY COMMAND FILE

```
.enable substitution
.enable global
.enable decimal
.enable quiet
.open #1 ti:
.sets $box "15"
.sets $expid "A"
;'$expid'
.sets $fdir "lb:[200,3]"
.start:
clr
.;----------make SKED date for file names----------
..find name of sked data file
        .sets $mmm <DATE>[4:6]
.;'$mmm'
        .sets $da <DATE>[1:2]
 ;'$da'
        .sets $yy <DATE>[8:9]
.:'$yy'
        .sets $dat $da+$mmm+$yy
        .sets $fdate <date>[1:9]
        .sets $ftime <time>
        .sets $dytim $fdate+" "+$ftime
 ;----------Is box free----------
        .Setf <erseen>
        sk ac/s '$box'
        .if <exstat> = 1 .data#1 Box '$box' is active. TOO BAD FOR YOU!!
        .if <exstat> = 1 .goto stop
skd lo [user]stest '$box'
 ;----------Test box----------
.ask [<true>] goon Want to run an experiment? (type no to exit)
 iff goon .goto exit
sk ab 15 y
.;----------Identify Conditions----------
 setn $wght 0
 sets $stat $box
.;----------Subject----------
.;Enter a ZERO for rat id, if you are not running a box.
.askn [0:99] $ratid Box '$box': Rat id
 if $ratid = 0 .exit
 ;----------Condition----------
.asks [0:70] $cond Box '$box': Rat # '$ratid' cond
.;----------session duration----------
 askn [0:1440] $sedu How long (in minutes) is this going to take?
 setn $sedu $sedu#6
 ;----------Mass----------
 .
 .enter a mass of 0 if the rat was not weighed
 ;
        askn [0:600] $wght Box '$box' Rat # '$ratid'  Mass
.;----------pre post----------
 .
 .Is this pre, post, or other? pre=a, pos=b .other=c
sets a "A"
sets z "Z"
setn an 'a&v'
setn zn 'z&v'
getlet
asks [1 1] $prepo Box '$box' Rat # '$ratid' pre=A, post =B  other=c
setn prepon '$prepo&v'
```

```
        .sets $dfid $fdir+$expid+$dat+"d."+"'$prepo'"+"'$ids'"
        .sets $nfid $cond
.;      .sets $nfidv #expid+$dat+"n."+"'$ids'"
.;----------------------------Load and Modify--------------------------------
sk lo [user]activity '$box'
.ift <erseen> .goto stop
.data #1 modifying station '$box'
        sk m'$box'/s a0 '$ratid'
        sk m'$box'/s a1 '$wght'
        sk m'$box'/s d0 '$sedu'000
        sk m'$box'/s a3 'x'
        sk open c '$dfid' '$box'
        sk open n "'$cond'" '$box'
.;-----------------------------Start session---------------------------------
.ask [<true>:1200s] $goon start the session?
.iff goon .goto nope
sk st '$box'
.exit
.nope:
.ask [<true>] goon Are you sure?
.iff goon .goto start
sk ab 15 y
.data#1 Oh well, maybe next time.
.exit
.;-----------------------------SKED load error-------------------------------
.stop:
.;
.;ERROR in loading state table in station "$box', procedure terminated.
.exit
```

APPENDIX F

```
_HSC002$DUA7:[ZIRIAX]ACTIVITY.SKD;1                    29-AUG-1990 07:50

dim a-40
\0      subject #
\1      subject weight
\2      session length in minutes
\3      pre & post session data
\4      total counts r1+r2+r3+r4
\5      r1
\6      r2
\7      r3
\8      r4
\9      time
\10-19  tenths of the time
\20-39  IRT in J(1) units of time
\40     IRT bin size (J(1))

list d-10',1',1' \d- time variables
list j-1",1"     \IRT BIN size
list x-10

s.s 1
s1:
        #r1!#r2!#r3!#r4:set d(1)-d(0)/10,d(2)-d(1),a(9)-d(1),a(40)-j(1),j(0)-j(1)--->s2
s2:
        1':add a(2)--->sx
        d(1)#t:set d(1)-d(2);add x--->sx
        d#t:type 0,0,!,"activity done",!--->s3
                #r1:add a(5),a(4),a(x);z2--->sx
                #r2:add a(6),a(4),a(x);z2--->sx
                #r3:add a(7),a(4),a(x);z2--->sx
                #r4:add a(8),a(4),a(x);z2--->sx

s3:
        5"--->stopcollect

s.s 4           \IRT distribution
s1:
        #z2 set i-0--->s2
s2:
        j#t set j-j(1);if i<20 [add i]--->sx
        #z2:add a(i+20);set i-0, j-j(1)--->sx
        #z1:--->s1
```

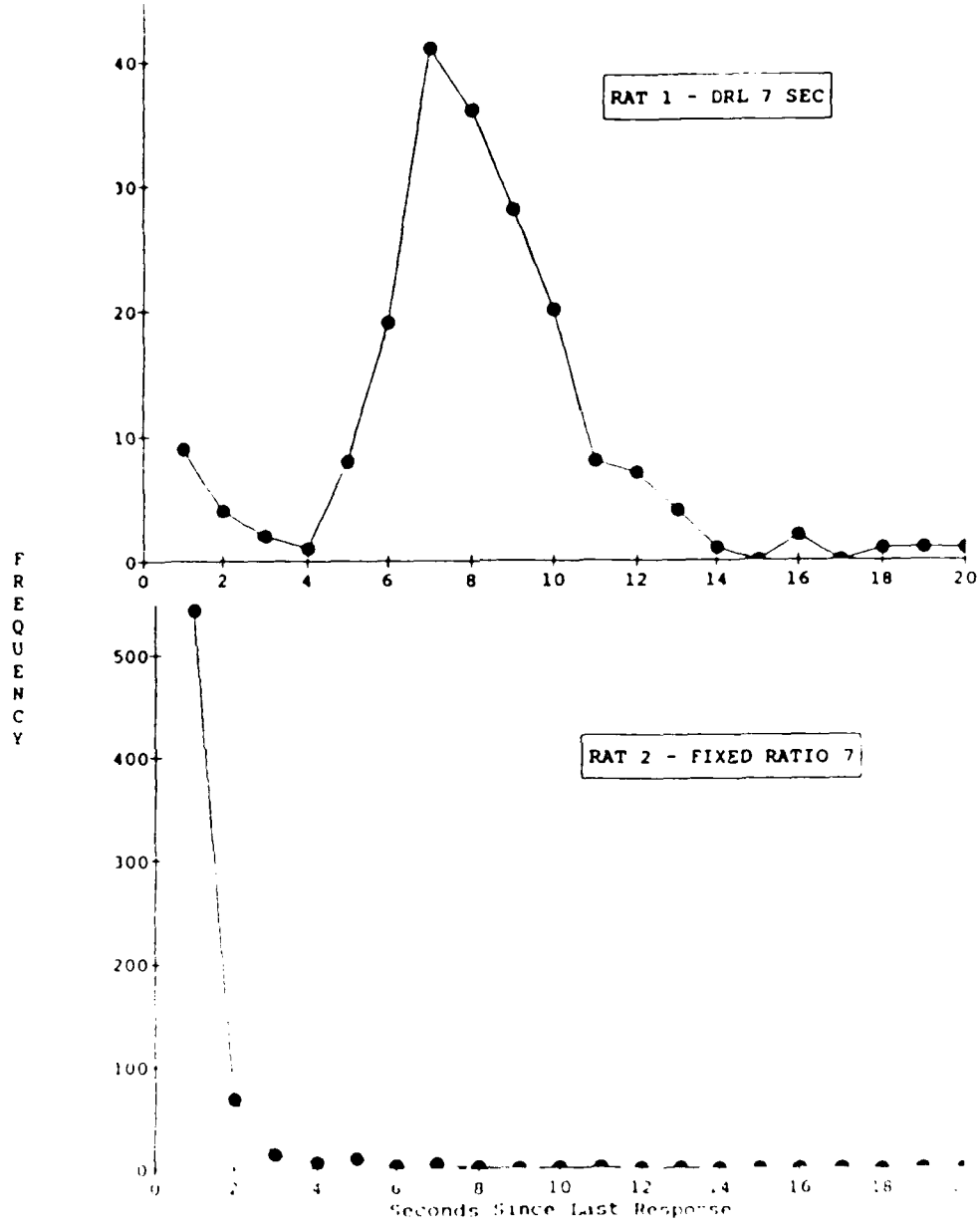


FIGURE 1: Interresponse times on DRL and FR schedules.

UES REPORT

John Martin Taboada

Summer 1990

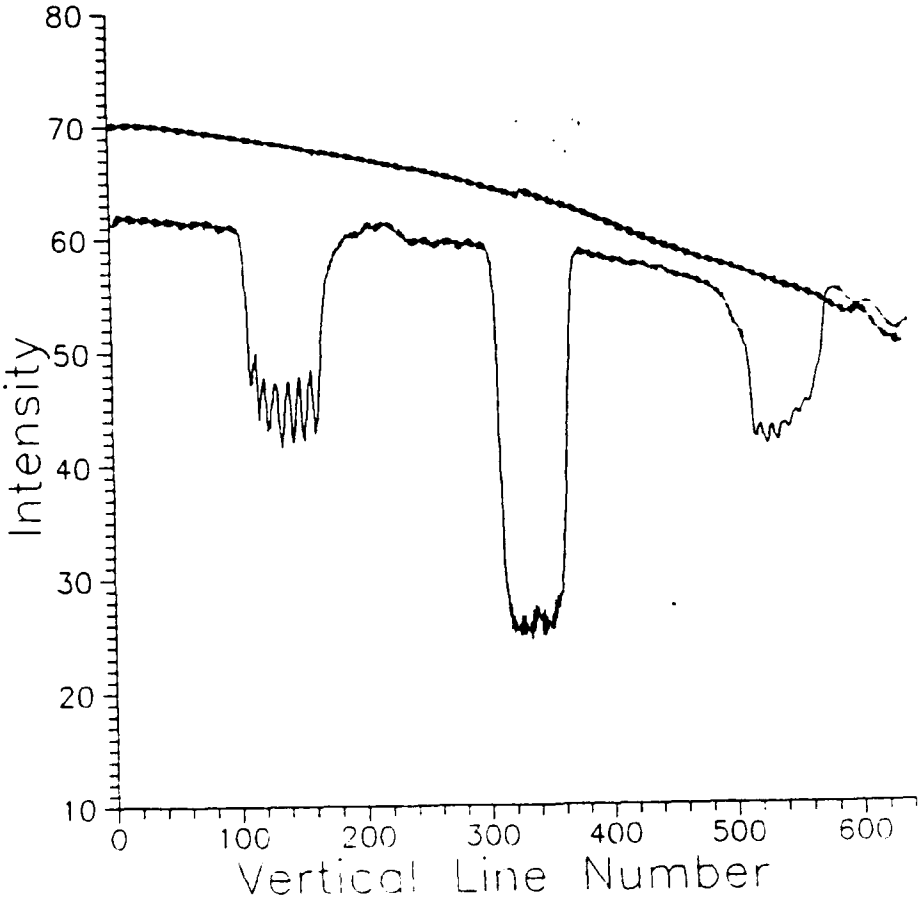
UES REPORT -- Summer 1990

John M. Taboada

This has been my second year to participate in the Air Force Apprenticeship Program. I was assigned to the Vision Biophysics Laboratory in the Clinical Sciences Division of the School of Aerospace Medicine and my mentor was Dr. Russel Burton, Chief Scientist of the USAFSAM. The project I worked on was to take a commercially available video digitizer and modify it in order to act as a spectrum analyzer for various cost effective laboratory applications.

The video digitizer used in this work was a SV1000 by Codeware. It is an inexpensive digitizer about the size of a deck of cards which is connected to the printer port of an IBM PC. The individual who makes these digitizers and who also provides a Basic program to operate the device is Frank Lyman of Nashua, New Hampshire. My first order of business was to get the video digitizer working by setting some software parameters unique to the laboratory computer system. Using the program that came with the unit, it was relatively easy to capture an image and display it on the monitor. The next step was to figure out how the pixel information of the image was stored. As it turns out, the images would be saved into four each sixty-four kilobyte files of ASCII characters. There was some higher order to

the files and after I figured it out, I proceeded in writing a program to do a vertical collapse to obtain an intensity profile of the captured image from the raw data. The program takes the average ASCII value of each of the 640 vertical lines and then saves them into an array of equal size. Once this data array of 640 elements is acquired, a program called Grapher can then be used to plot the data. A sample graph which contains two images, one of a stripped object and one of a plain surface are shown below: The stripped object is clearly revealed in the highly structured intensity graph.



The actual image of the plain surface is progressively darker towards the right of the screen, and as the graph shows, the intensity decreased towards the right. Also, there was enough resolution to identify the six bright stripes within a dark region of the stripped object. After further work in debugging the data files, the next step was to incorporate a graphing and printing routine into the Turbo Pascal program. For this I used some graphing routines from Quinn-Curtis' Science and Engineering Tools. The last and final step is to combine both Frank Lyman's program, which captures the images, and my Pascal program, which analyzes the data and prints out a graph of the vertical collapse of the images. Once that is completed, this inexpensive data acquisition circuit will be combined with a simple diffraction grating to yield a multichannel spectrometer.

ACKNOWLEDGMENT

I wish to acknowledge the helpful direction and instruction from Dr. Paul Griffin, summer faculty member from Georgia Tech University; Will Robinson, coop student; and David Gaines, graduate student.

WEAPONS LABORATORY

Phase Conjugation and

Beam Coupling

David Cochrell
Captain Karl Gass
August 1, 1990
KAFB Weapons Laboratory AROM

Working at Kirtland has been the greatest opportunity of my life. This experience has given me the chance to work in an environment with professionally trained individuals. These people have taught me to deal with scientific problems in a mature fashion. I would like to thank Captain Karl Gass for accepting me as an apprentice under his guidance. Captain Gass has kept me busy with a variety of experiments. Not only did Captain Gass accept me as an apprentice, but he accepted me as his friend, which made working with him an enjoyable experience. I met Karl through the Mentorship program offered to me by the gifted program at West Mesa High School. Since that time Karl has helped me with school, work, and personal problems. Furthermore, I would like to extend my appreciation to Mr. Bruce Liby for taking the time to explain the importance of the experiments I worked on and teaching me the techniques that I needed to perform these experiments. Mr. Liby has helped me a great deal throughout my apprenticeship. Mrs. Pat Whited deserves great thanks for coordinating the Apprenticeship program and making sure that I was happy with my mentor and the program. Universal Energy Systems made my apprenticeship possible and also paid me so I would like to thank them too. I would also like to thank Mike Wick for his patience, time and help. These people and many that I did not name helped me have a successful and enjoyable apprenticeship.

The experiments that I worked on dealt with phase conjugation and beam coupling in barium titanate. I was asked to work on these experiments because in the past scientists have observed unexpected results caused by the barium titanate crystal while working on a project. These results were either unexplainable or else the scientists were unable to get these results again by repeating the experiment. My job was to simulate the experiment and find out why the results occurred.

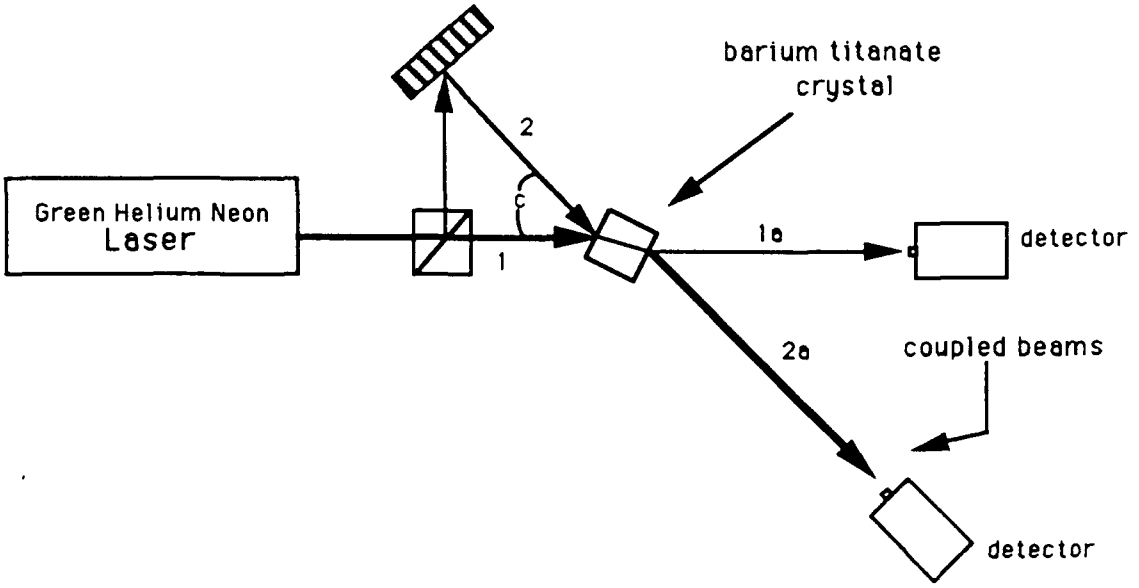
Barium titanate is a photorefractive crystal capable of phase conjugation and beam coupling. During my experimentations I used both a helium neon laser and a visible diode laser to obtain data. In

order to observe two beam coupling I sent a laser beam into a 50/50 beam splitter and sent the laser beam into the barium titanate crystal at two separate angles, but entering the crystal at the exact same point. I measured the intensity of each beam before it entered the crystal and after it had exited the crystal using two detectors connected to a Macintosh computer where I could observe and record the results. This experiment can be seen in picture #1. Phase conjugation can be observed by sending a laser beam through a glass slide and into the barium titanate. When phase conjugation takes place the laser beam will travel back to the slide and reflect off the slide therefore proving that phase conjugation has taken place. This can be seen in picture #2.

I did not go into great detail experimenting with the self-pumped phase conjugation, but I did observe it. I focused most of my time on two beam coupling. After filtering the beams equally so that the detectors could read their intensity I found that beam coupling did not happen instantly. By rearranging the gratings in the crystal using white light I observed how the crystal coupled the beams over a period of about fifteen minutes. I found that I got the greatest coupling using as small an angle as possible at angle C shown in picture #1. With angle C at 21.58 degrees and taking 10 samples a second for fifteen minutes I observed the results in picture #3. Beam # 1a began at 13.2 volts (V) and beam #2a began at approximately 1.2V after 10 seconds beam #1a dropped to 12.4V and beam #2a raised to 1.6V. After 30 seconds beam #1a had dropped to 11.9 and beam #2a had raised to 1.9V. After ten minutes beam #1a had dropped to 10.9V while beam #2a raised to 2.2V. Since beam #1a is still transferring its power to beam #2a the beam coupling is not complete. 7.5 minutes into the experiment beam #1a has dropped to 9.9V and beam #2a has raised to 2.8V. After 11 minutes beam #1a has dropped to 9.5V and beam #2a has raised to about 3.1V. For the remaining 4 minutes the beams stay at about these voltages, thus completing the beam coupling.

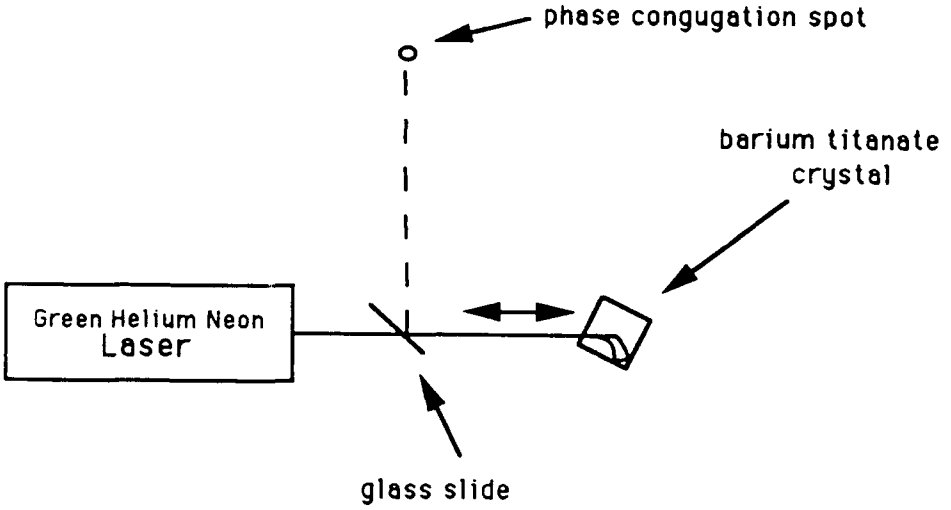
The Apprenticeship program has helped me a great deal by giving me the opportunity to explore a career that I am interested in. This program has helped me understand what it is like to work in a professional environment. I have learned about subjects I never thought I would get the chance to. Thank-you again to everyone who made it work.

TWO BEAM COUPLING

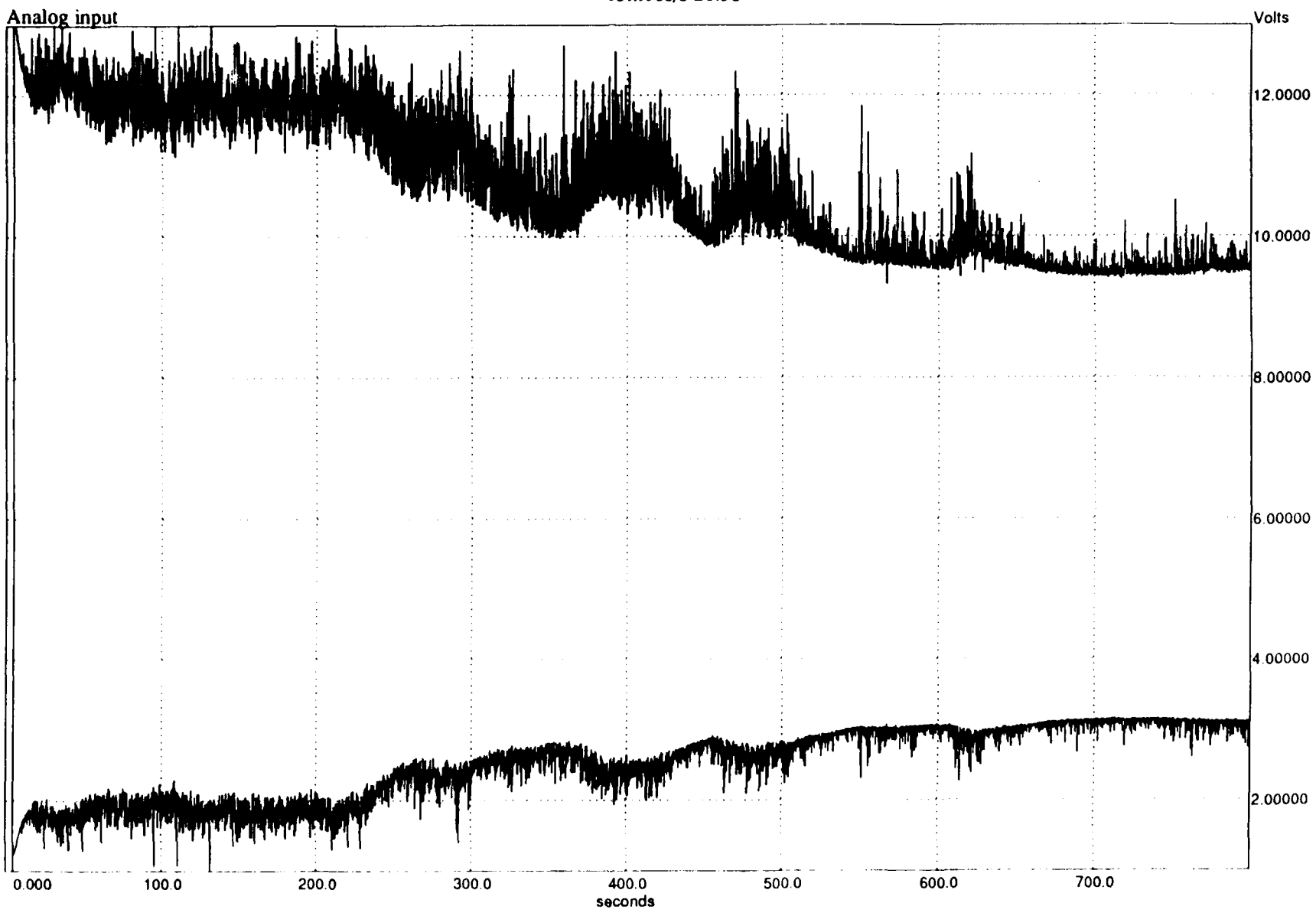


picture # 1

SELF-PUMPED PHASE CONJUGATION



picture #2


15m10s/s 21.58
Analog input
Volts
12.0000
10.0000
8.00000
6.00000
4.00000
2.00000
0.000
100.0
200.0
300.0
400.0
500.0
600.0
700.0
seconds

Greg R. Hays

Paul D. Hillman, Ph.D.

Air Force Weopons Lab

Semiconductor Laser Branch

August 10, 1990

Acknowledgments

My summer mentorship at the Air Force Weapons Lab proved to be quite beneficial. I am very intrigued about the career field of physics and in laser technologies. I would like to thank everybody in the Semiconductor Laser Branch for aiding me in my works and explaining what I was unable to understand. I would like to thank Major John C. Frazier, USAF for aiding me in obtaining a Cooperative Education (Co-Op) position in the Weapons Lab next year. Most of all I would like to express my gratitude to my mentor, Paul D. Hillman, Ph.D. He was always willing to help me comprehend the projects I was working on.

Research

My experience at the lab was divided into three parts. The first three weeks were spent as a lab aide for an experiment on nonlinear coupling of laser diodes. The next stage was to become more familiar with the lab's equipment by creating a poster of all the equipment that is available in the lab. The final stage was an experiment to measure the index of refraction of certain crystals with laser diodes.

The first stage of the mentorship was to be a lab aide on an experiment. The experiment was to try to couple two semiconductor laser diodes using crystals. First, two individual laser diodes were brought to specific temperatures and current levels so that their frequencies were the same. The laser beams were passed through the crystal and which steered them into the opposite laser's cavity causing the lasers to lock into phase and therefore be coupled. The crystals were used to aide in the process of sending a quality beam into the opposite cavity. Due to the shortness of lab tables within the lab, the table was temporarily passed on to another experiment. Therefore, no concrete data was taken and no conclusion have been made.

The next two weeks were spent creating a poster of all the equipment in the laboratory. This was a necessary task that needed to be completed, and it also was a method of becoming more familiar

with the equipment in the laboratories. By inventorying all the equipment, each item's function and use became clear.

The final stage was an experiment that measured the index of refraction of crystals. A lower dispersion value of the crystals should improve the locking characteristics of photodiode lasers using photorefractive techniques. Using a Michelson interferometer (Fig. 1), there can be a change in optical path length between the two arms that can be used to help measure the index of refraction in a crystal.

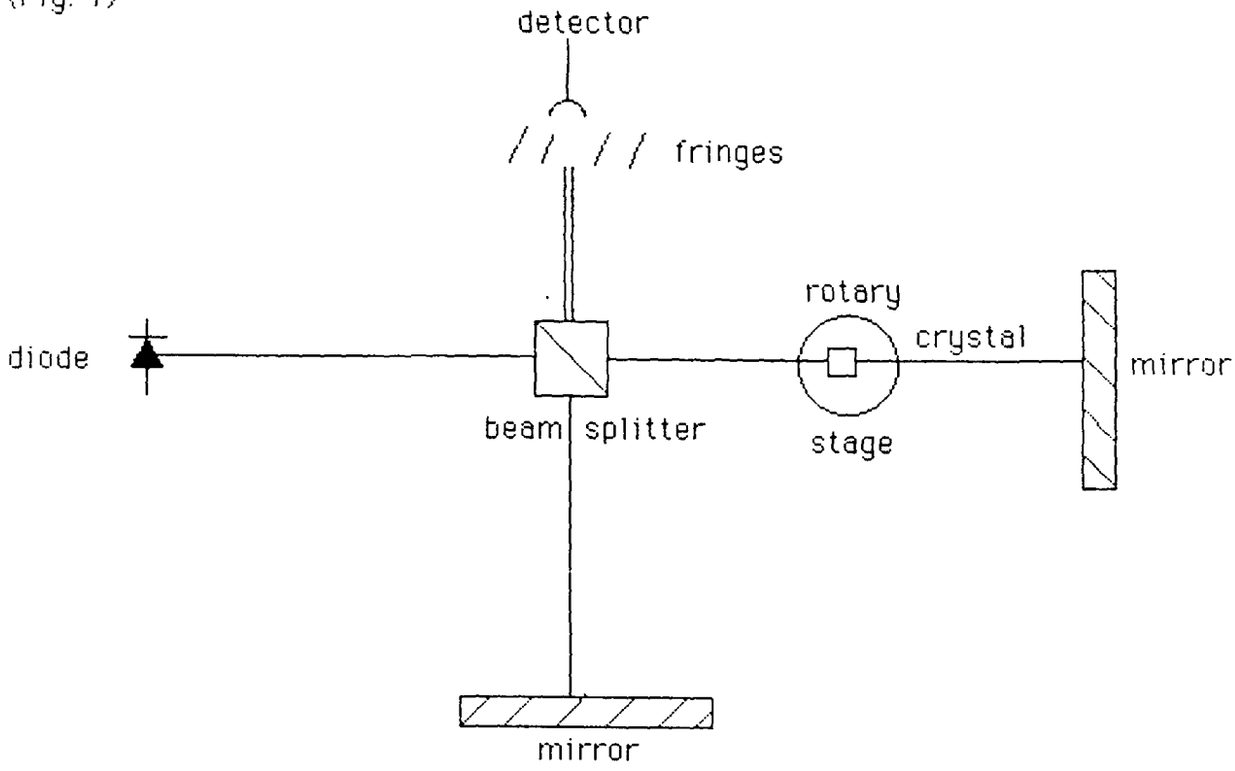
In a Michelson interferometer, a laser beam is sent forward into a beam splitter that divides the beam into separate parts and sends each beam on a different path. One beam travels in one direction, reflects off a mirror, then back through the beam splitter, and then on to a detector. The other beams passes first through a crystal that is placed on a rotary stage and then on to reflect on a mirror. Then it returns back through the crystal, through the beam splitter, and then on to the detector where the two beams meet and interfere. The interference created patterns called fringes (Fig. 2).

By rotating the stage that the crystal sits on, the optical path length is changed and the detector will detect fringes passing by. The stage was rotated five degrees at a steady velocity over the period of ten seconds. As the stage turned, the beam was refracted in the crystal, therefore changing its path length. By the use a silicon detector, points of high and low intensity were plotted out with a chart recorder (Fig. 3). Each time a fringe passed by the detector, the

optical path length in the crystal changed exactly one wavelength. The predicted number of waves shifted per degree was plotted on figure 4. On figure 3, a peak of a wave represents the highest point of intensity of that fringe. The lowest point in a trough represents a point of lowest intensity. By the use of taking points of high and low intensity from the plot, the index of refraction can be fitted.

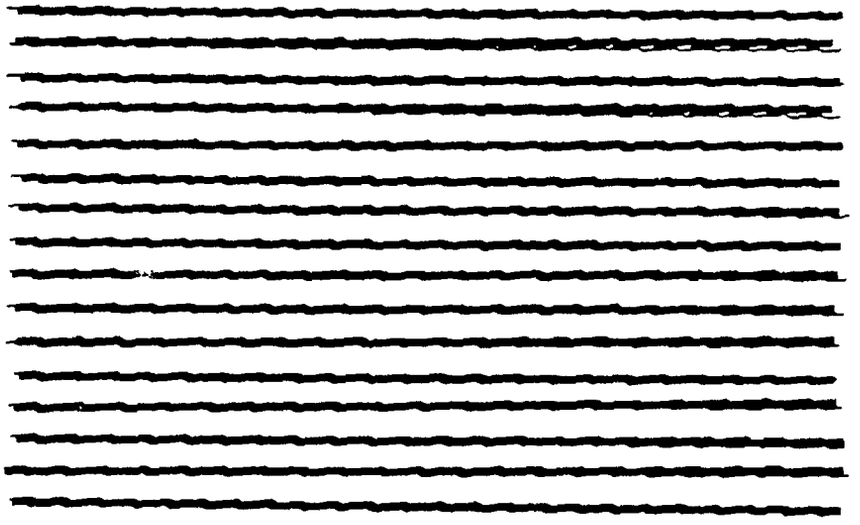
Due to problems with the computer program and also that time was short, this experiment was also unable to be completed before the paper was due. However, I will return after the mentorship program is completed and continue to work on the experiment.

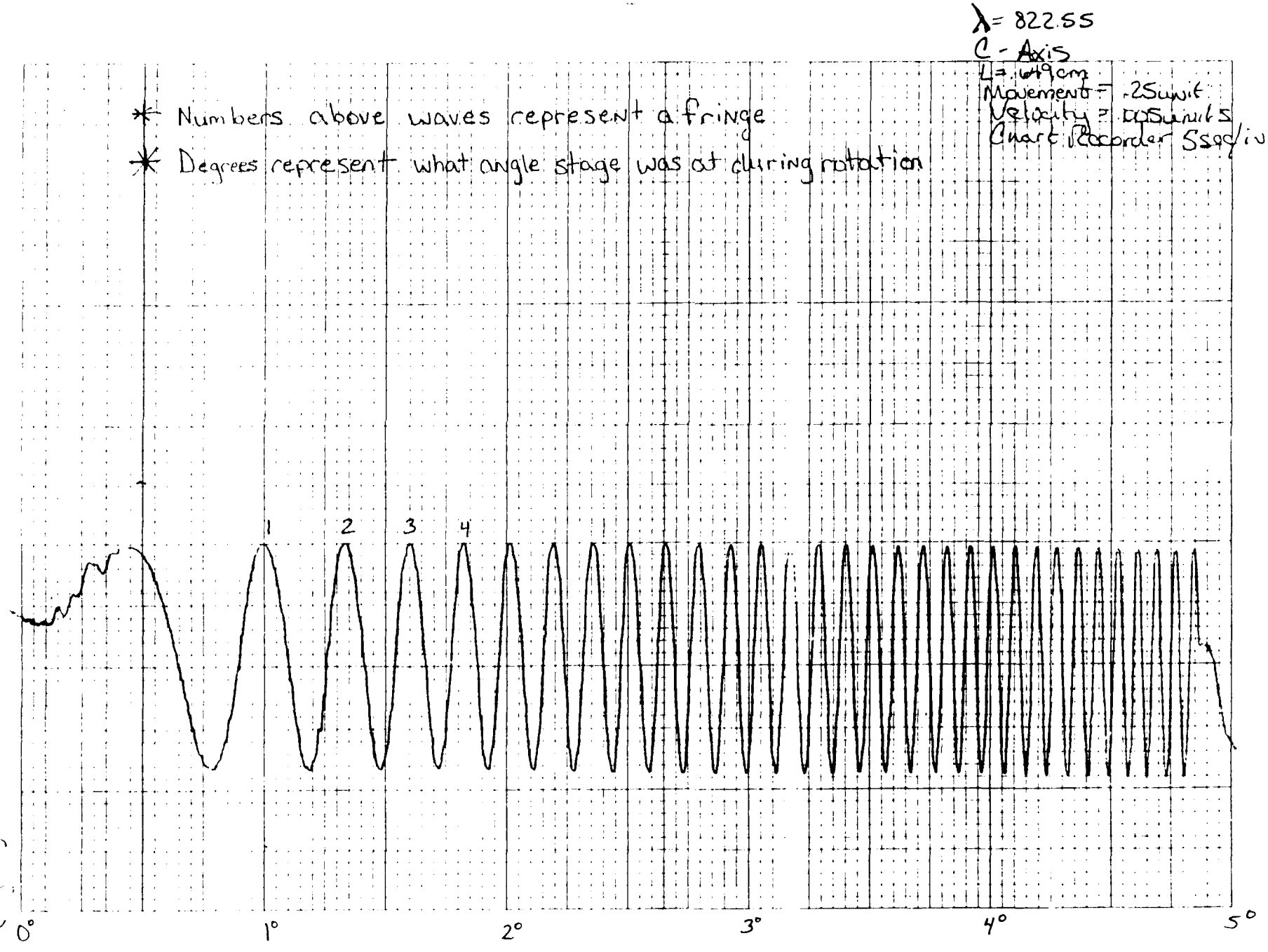
(Fig. 1)


detector
fringes
rotary
crystal
mirror
diode
beam splitter
stage
mirror

(Fig. 2)

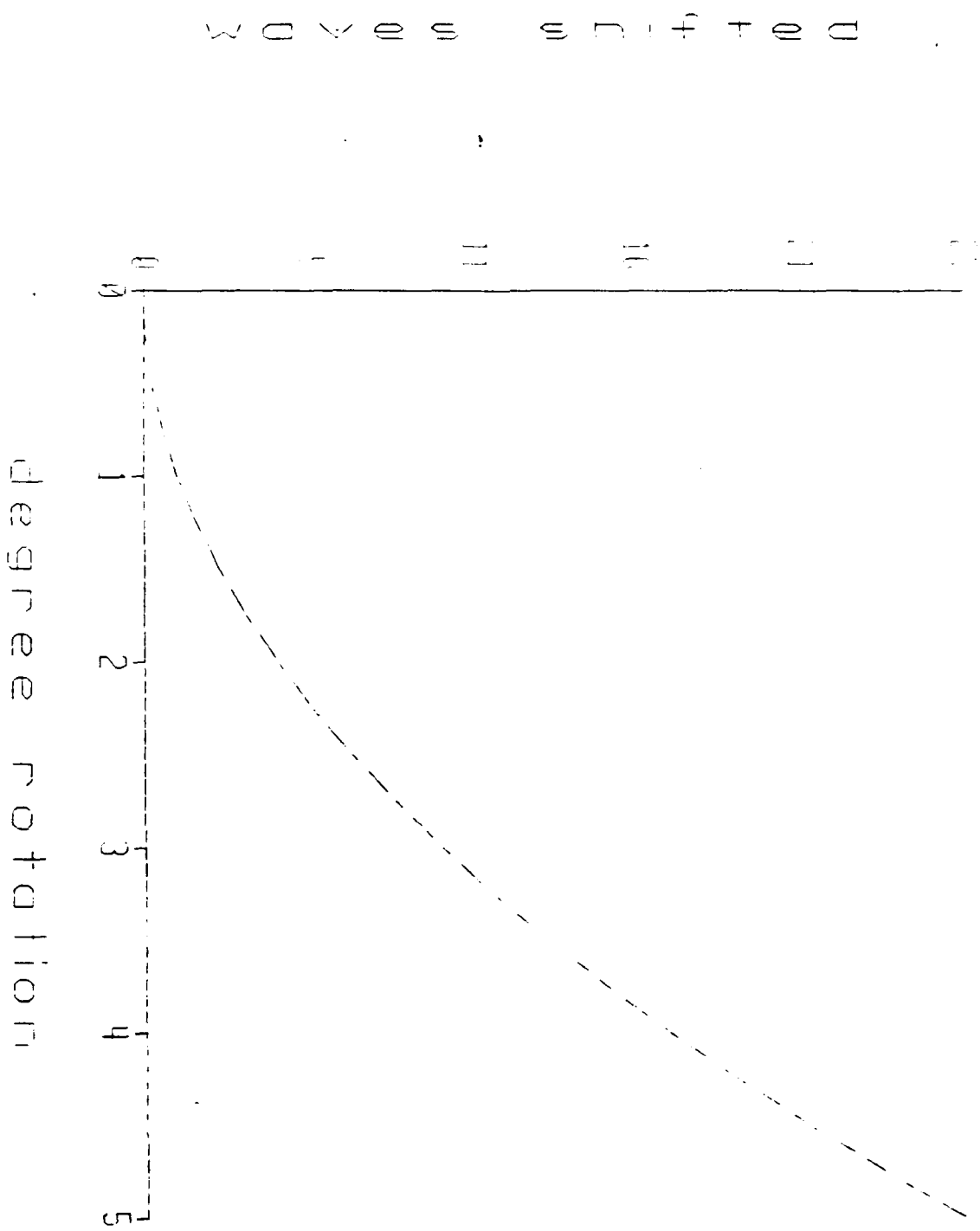
diagram of optical fringes





(Fig. 3)

(Fig. 4)



A Study In C

David Knapp

with the aid of
mentor Captain Keipert
at the Weapons Lab/
ARDK, building 434
from June 18 to August
10, 1990.

Introduction

My summer apprenticeship program was done over at the Air Force Weapons Lab at Kirtland Air Force Base in Albuquerque, New Mexico. I worked at building 434 in ARDK. The summer apprenticeship included a great deal of work with computers. Tours of other labs were given. I worked under the direction of Captain Andy Keipert. This report tells the main projects that were started from June 18 to August 10, 1990.

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Acknowledgments

Many thanks to:
Captain Andy Keipert
Lieutenant David Cohen
Lieutenant Ken Floyd
Captain Joe Axtell
Sergeant Andy Ruggerio
Mr. Jeff West
Major Robert Ligday
and of course the countless others who have worked to make the summer apprenticeship program a success.

General Description of Research

A. What Was Done

At the Air Force Weapons Laboratory in ARDK at building 434, I undertook the goal to learn the programming language C and to improve my overall computer skills. As far as C programming was concerned, I was able to learn the C programming language as I programmed a laser beam simulator/data plotter. This program allows one to take a few specifications of a laser (the range, the divergence, and the power) and to transform them into a visual diagram of the strength of the beam as the range increases. The next programming project was to computerize the orders system for the branch. Initially, I was set to the task of creating the basic menu for the system in order to allow other programmers in the office to fill in the missing parts. Later, it was discovered that ready-made software was available on the Macintosh to do the same job. Currently, a scanner is on order so that forms may be scanned in and processed by the system. In another project, I sought to improve my computer art skills. This was done by creating the visual effects for charts for briefings on lasers. FAX cover sheets were also produced using the same programs. Computer Aided Design was also briefly explored.

B. Why What Was Done Was Done

The laser simulator/plotter program was programmed because of a need expressed by Captain Keipert of a system that would produce an output more understandable than a long list of numbers as would be found when using a spreadsheet to do comparable work. The computerized orders system was needed in order to cut down on the mountain of paperwork that is needed for just one TDY (Temporary DutY) or business trip. The visual charts were required for briefings. The FAX cover sheets were required for the sending of faxes all across the country in a civilized manner. The computer aided design exploration was needed in order to develop the capability to design things if the need arose.

C. Application of Results

The results of my efforts can be applied in many ways. First of all, the laser simulator/data plotter can be used by scientists to get a visual idea of his/her particular laser data. In further stages, the laser simulator/data plotter will be able to project a realistic estimate as to the effectiveness of the system in a combat application. Second of all, the acquisition of valuable C programming skills enhances my ability to contribute to any laboratory. Often, custom software is needed to solve unique problems that require a computer. For instance, data analysis software is usually custom written to interpret data produced by instruments in the lab. Third of all, some scientists have difficulty communicating their data in a

presentation. By assisting in creating visual presentations, I was able to learn some of the methods for creating a professional presentation of research.

Detailed Description of Research

A. Materials and Methods Used in Learning C

For the learning of C programming, I used a Turbo C 2.0 compiler from Borland running on a Zenith 80286 MS-DOS compatible with an EGA display. For printing, I used a Hewlett Packard Laserjet II. I used The Turbo C reference guide and The Waite Group's Turbo C Programming for the PC as technical references for learning the language.

My work started by attempting to grasp some of the more advanced features of Turbo C. This was done by reading part of the Turbo C Programming for the PC. Work on the Laser Simulator was started by creating a main program routine. Later, more routines were added to the main module.

The first routine added to the main module had the function of getting information about the specifications of a laser from the user. Keyboard scanning statements were used in this module. The maximum range, the divergence (theta), and the power of the laser were asked for in this module.

The next module was a very basic computational module designed to test the equations to be used in more complicated routines. This module computed the beam radius, the beam area, and the beam power per square meter at the selected maximum range. Refer to reference page one for the complete equations used in this and other modules.

A diagram of the program control is also included in the reference pages.

The third and fourth modules added were used to create some graphics. One module was used to initialize the graphics. Another was used to display text and color on the screen. The graphics initialization module was used twice to set up the graphics. It was used once for the title screen and once for the plotting screen.

The fifth module created was designed to loop through the same equation while incrementing the range until it reached the maximum range specified by the user. The output from this module was channeled crudely to the screen as a long list of numbers. This subroutine served to test the looping accuracy and mathematics. It was later transformed into the next module which was created to actually plot the data in X-Y format on the screen. This subroutine created a sloping graph showing the power loss per square centimeter as the range increased.

The last module made was used to create a color coded picture of the laser beam signifying the relative power levels of the beam as the range increased. The module calculated the beam power at incremented ranges (640 total increments because of the screen being 640 pixels across) and checked the calculated power against the power at range one in order to decide which color to assign the beam at that location. Sixteen colors were used out of the sixteen available in EGA (Enhanced Graphics Adapter).

The beam area was calculated in the same way in order to have the program decide the Y width of the beam. Hence, the module plotted a multicolored isosceles triangle representing the beam of a laser. This output was made to appear below the curving plot of the sixth module. In addition, during the increments the program was made to print the beam power at a special location on the screen so that the average laser simulator/beam plotter user could see both the color coded data and the actual number for the beam power per square centimeter.

B. Materials and Methods Used in Computer Art

The computer programs used in creating computer art for visual charts and fax cover sheets were Windows Paint, IPrint, and MacPaint. The computers used in creating computer art were a Macintosh SE and a Zenith 80286 compatible. The printers used were a Macintosh LaserWriter II and a Hewlett Packard Laserjet II. Charts were sketched and then transformed into a computer drawing. Fax cover sheets were designed with a great deal of imagination and a set of specifications laid down by the future users of the cover sheets. I managed to learn how to use Windows Paint, IPrint, and MacPaint through experience without requiring the aid of a manual. About 50 charts and cover sheets were created in this manner during the course of the summer. The experience gained in the creation of the charts will be helpful when applied to desktop publishing projects.

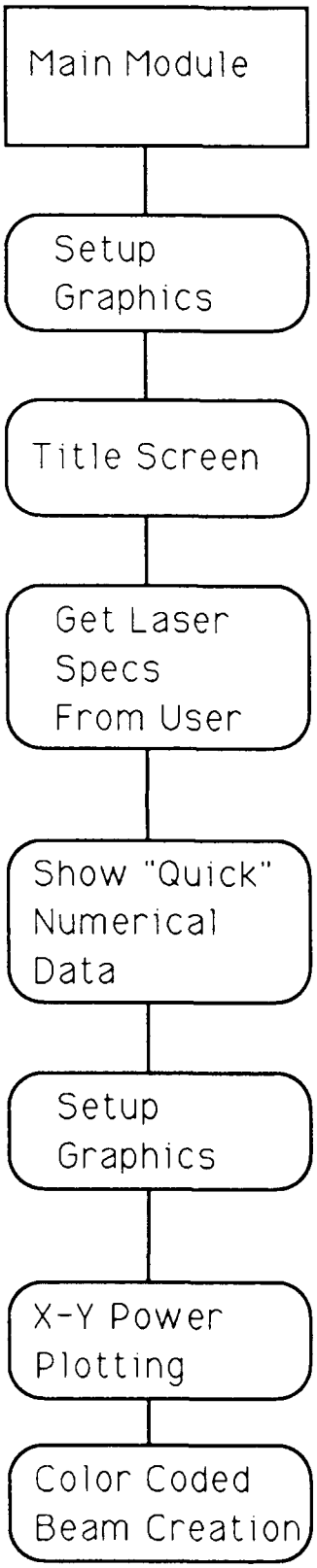
Results of Work

While programming the laser beam simulator/data plotter I learned a lot about the mathematics that are involved in calculating the strength of a laser beam at various ranges. I also learned that although programming can be a very interesting and rewarding experience, it can also become a little boring and drab. Therefore, I found out that I do not wish to be a full-time computer programmer. Computer programming is a valuable skill that comes in handy. Clearly, lab work alongside of computer programming makes things much more interesting. Perhaps my view will change in time. The laser beam simulator/data plotter has the first stage done. Unfortunately, at press time a program could not be found that would dump an image from the computer screen onto the printer. Therefore, actual screen shots of the program were unavailable. The second stage will be to transfer the program over to a VAX in order to interact it with another beam propagation model program already done. This second stage is likely to be accomplished during the school year as I transfer to another program that will allow me to work here. A third stage of the program will be the effort to take the model and add in factors for possible effectiveness in a combat environment. This will include the capability to test a particular laser's effective use against targets such as tanks, missiles, and planes. Source code of the program is

available upon request.

I found that creating charts and cover sheets was quite enjoyable. About 50 charts and fax cover sheets were created using some skill and a little creativity. Creating them allowed me to work with recent desktop publishing and drawing programs that increased my skill in working in computer aided drawing and design. It is unfortunate that AutoCAD wasn't working until the end of the apprenticeship program. By then, it was a little too late to do anything very useful with AutoCAD 9.0 except a very basic exploration of its features. Overall, the computer drawing was very interesting.

Flow Chart of Program



Equations Used In Program

Beam Radius = (Theta * (Range/640) * increment counter)/2

Beam Area = PIE * (Beam Radius ^{2})

Beam Irradiance = User Defined Total Laser Power / (Beam Area * 10000)

↑ Conversion Factor

Insights

The apprenticeship program was a valuable educational experience. It gave me a feel for the standard 40 hour work week. It was also nice to be in a noncompetitive atmosphere. I wish that I could have been able to do more lab work. The lab that I was supposed to work on to do my original project, Laser Foil Analysis, was unreachable due to a classified project being conducted there. Also, the project Laser Foil Analysis was already completed by the time I came to the lab. However, I did get to tour other interesting labs and see what things others did. Hopefully, next year I will be able to work a little more in an actual laboratory instead of the office doing support work.

FINAL REPORT
OF
SUMMER MENTOR:

AARON LAING

LT COL RONALD THOMAS
DIRECTOR, COMMUNICATIONS-COMPUTER
TECHNOLOGY SYSTEMS DIRECTORATE

10 AUGUST 1990

The summer mentorship program taught many things. Firstly, a great amount of computer operation fundamentals was learned; also, the social skills necessary to function in a serious work environment were acquired. Throughout the eight week period I was given the opportunity to work in several different areas performing several different tasks. Because of the diverstiy of the jobs I now possess knowledge about many different computer systems and also an understanding of how a network cooperates to keep the system functioning.

Although I was able to work in several different settings, my basic job was drawing charts and diagrams on various computers using various software packages. The first few weeks were spent drawing diagrams of a system of four computer chips that would work together to decompress computer graphic information sent from a high reslolution monitor through the Ether net to another terminal on the network. Also, a diagram of a cooling system that is to be placed on board a satellite was drawn. All of the diagrams for both the decompression chip and the cooling system were done on an Apple Macintosh II using the Persausion software package. The system just mentioned is perhaps the most user-friendly hardware/software at the Weapons Lab. (Attached are pictures of the chips and the cooler, in color.) As mentioned above, chart designing also consumed some of my time at the Lab. Using the Easyflow software package (a package designed for creating organizational charts) I created about a dozen diagrams showing the breakdown of the Travel Order Generation System (TOGS). I am the only person in the SC division who knows how to use the

package so I was an asset to the organization as a result. After completing the charts I was assigned the job of importing the TOGS forms into an account on the uservax and editing them in the Wordmarc format. This was a very time consuming task and is also where I finished up my summer mentorship experience.

The summer mentorship program gave me an opportunity to learn many things and also gain a bit of useful experience. I was treated the same as the other people in the SC division with the exception that I had to be taught everything. Because of the patience that my mentors and co-workers displayed I was able to learn quickly and now I have much useful computer knowledge and, more importantly, I have learned how to function in a true-life work setting. The social experience I gained through this job should, and will, help me in future situations in which a straight-forward and business-like approach will be mandatory. This, I believe, is the most important skill I learned this summer.

To conclude this report I would like to say that I feel that programs such as the one I participated in are highly beneficial to young people interested in not only succeeding, but exceeding. The experience gained through such programs is invaluable and I hope that more programs like it are opened to adolescents that express an interest in a scientific or computer related field.

Acknowledgements

I would like to thank the U.S. Air Force Wepaons Lab at Kirtland Air Force Base for supporting the summer mentorship program. Specifically, I would like to thank Lt. Col. Thomas for requesting me in his division; Lt. Kvasnak and Capt. Forker for employing me and showing me how to use the Macintosh; and all of the civilians in SCP who paused from their work to unlock computers, undelete the things which I deleted, and show me how to use computers which cost more than the BMW which I hope to own someday when I learn to apply everything which I am learning.

ST 1
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IF EQUAL
IF FLAG
IF ENABLE

WATER CONTROLLER
WHITE
FR
H_2O

STATISTICAL ANALYSIS OF CONE PENETROMETER DATA

KERIM MARTINEZ

FINAL REPORT

SUMMER/1990

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH
HIGH SCHOOL APPRENTICESHIP PROGRAM

UNIVERSAL ENERGY SYSTEMS, INC.

AIR FORCE WEAPONS LABORATORY
CIVIL ENGINEERING RESEARCH DIVISION
GEODYNAMICS SECTION

ACKOWLEDGEMENTS

I am deeply indebted to many people at work who have gone out of their way in order to help me. The people here at work take special interest in assisting and developing the skills of students such as myself. I thank the Air Force Office of Scientific Research and UES systems for the opportunity I have this summer. I would like to also thank and congratulate Pat Whited for her work and concern for the high school students who who work on the base. My mentor is always helping me in developing my research and scientific skills. Dr. Reinke takes time to informally talk to me in a straight-forward fashion that enables me to find an answer on my own. I would also like to thank Maj. John Gill for his enthusiasm and assistance. I also thank Capt. Robert Goerke for his help and instructional assistance in my research. I want to thank Capt. Bill Corson for his help in my cone penetrometer research. I want to especially thank Audrey Martinez for helping me understand different aspects of of my research. I would also like to thank Kent Anderson for computer and other assistance. I also want to thank Al Leverette for his help this summer. I would also like to thank Mrs. Eva Moya for important microwave safety tips. I have learned that I must enjoy my youth now before I mature into a civilized adult!

1.0 INTRODUCTION

The cone penetrometer tests have been used often in history for multiple purposes. The civil engineering community has benefited substantially from the use of the cone penetrometer. The cone supplies an abundant amount of information on the subsurface. The focus of this report is to statistically analyze data taken from a series of cone penetrometer tests using two electric cone penetrometers.

The cone penetrometer results used in this report were taken from a series of subsurface exploration tests conducted on McCormick Ranch Site, located on Kirtland Air Force Base. The tests occured between November 2, 1987 and November 15, 1987. The tests were done by the Earth Technology Corporation for the Air Force Weapons Laboratory. The purpose of the testing was to provide AFWL with stratigraphic information regarding the subsurface. This information is to be used to provide soil information beneficial in the modeling of ground motions due to a high explosive detonation. The results would also provide important statistical characteristics regarding the subsurface variability.

2.0 CONE PENETROMETER

Pushing a cone tipped probe into the ground has been an effective and widely used method of obtaining inforation on the subsurface. There has been a long history of Swedish, Dutch, American, and Russian involvement in the development of sophisticated cone penetrometer testing. There are three important values associated with penetrometer testing. These values are cone tip pressure, friction sleeve resistence, and friction ratio. The cone tip pressure is also known as the end bearing (Qc). It is equal to two times the force required to advance the cone. The measurements were recorded in kg/cm^2 or TSF (tons per square feet). The actual Qc pressure is the force divided by the total cross-sectional area of the cone penetrometer. The friction sleeve resistence is commonly called Fs. The friction resistence was also measured in TSF. The actual Fs measurement is the force due to friction divided by the entire friction sleeve area. The friction ratio is known as Fr. The friction ratio is the friction sleeve resistence divided by the cone tip pressure. The result is then multiplied by 100 to obtain the friction ratio (Ref. 1) This report will discuss only the results obtained from the cone tip pressure measurements. This was due primarily to the time limits involved with this

particular project. The two cones used in the tests were the conventional cone and the minicone. The cone penetrometer tests conducted at McCormick Ranch were part of several tests involved in the major CRAPS experiment conducted a few years ago.

2.1 CONVENTIONAL CONE PENETROMETER

The conventional cone penetrometer is the largest of the two electric cone penetrometers used in the subsurface exploration. It is a 15 ton capacity instrument. A specially designed truck (CPT) was used to deploy the conventional cone instrument into the subsurface. The truck weighs approximately 20 tons. The conventional cone penetrometer is primarily used for deep penetrations and to obtain a general description of the subsurface.

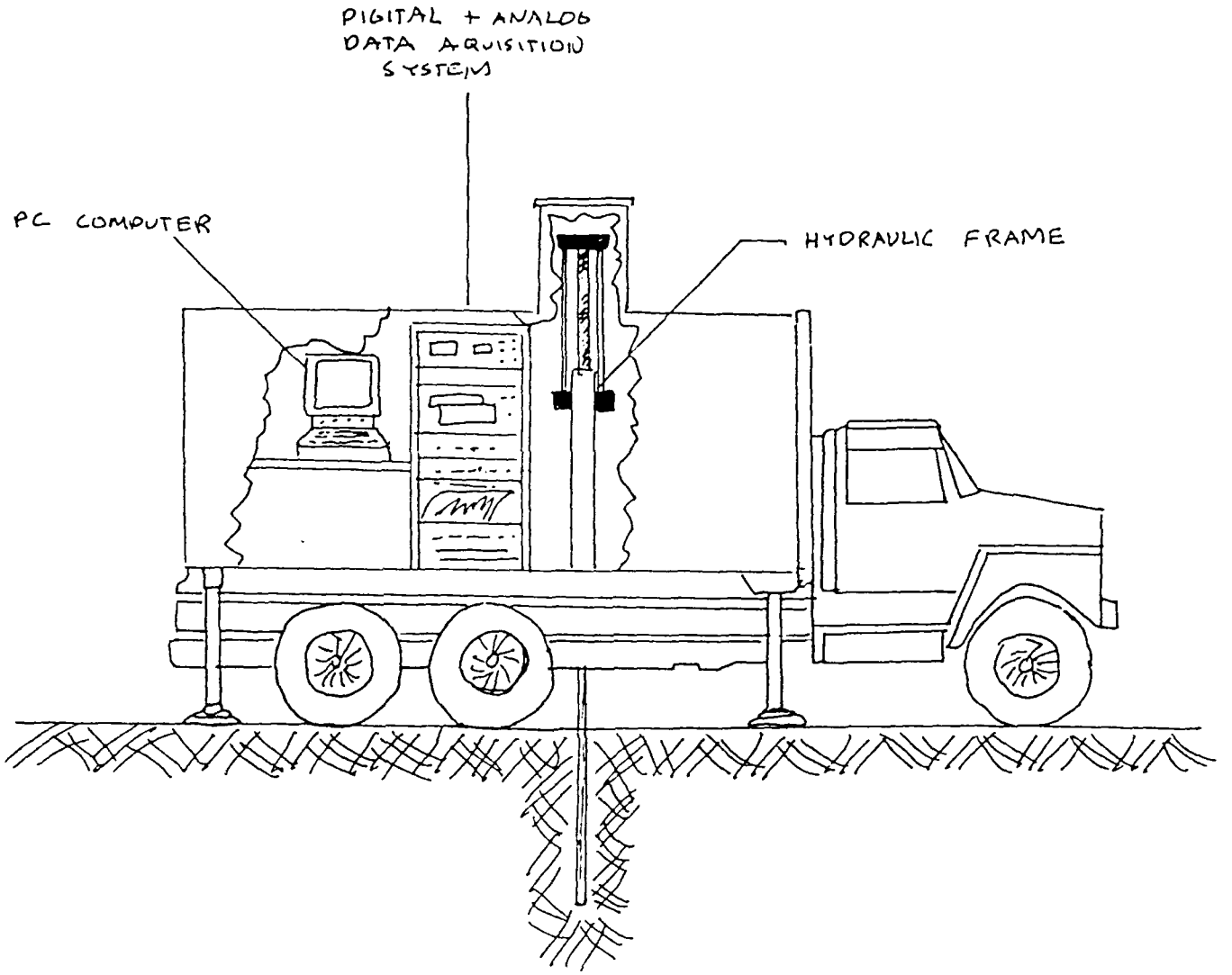
The probe is fully instrumented with strain gauges. These gauges allow simultaneous measurement of the cone tip pressure and friction sleeve resistence during penetration. A hydraulic load frame was used to push the cone penetrometer into the subsurface. Sounding rods were used to attach the cone with the vehicle above the surface. A cable located within the sounding rods transmitted the measurements obtained by the strain gauges continously into the on-board computer in the CPT truck.

These signals were then transmitted to the analog and digital data recorders located on the CPT truck. The data were then digitized for later analysis.

The cone penetrometer was pushed into the subsurface at a rate of 2 cm per second (Ref. 2). This rate is set by the ASTM (American Soceity of Testing Materials Standard). Testing may be performed in all possible weather conditions because all the equipment associated with the cone is self-contained.

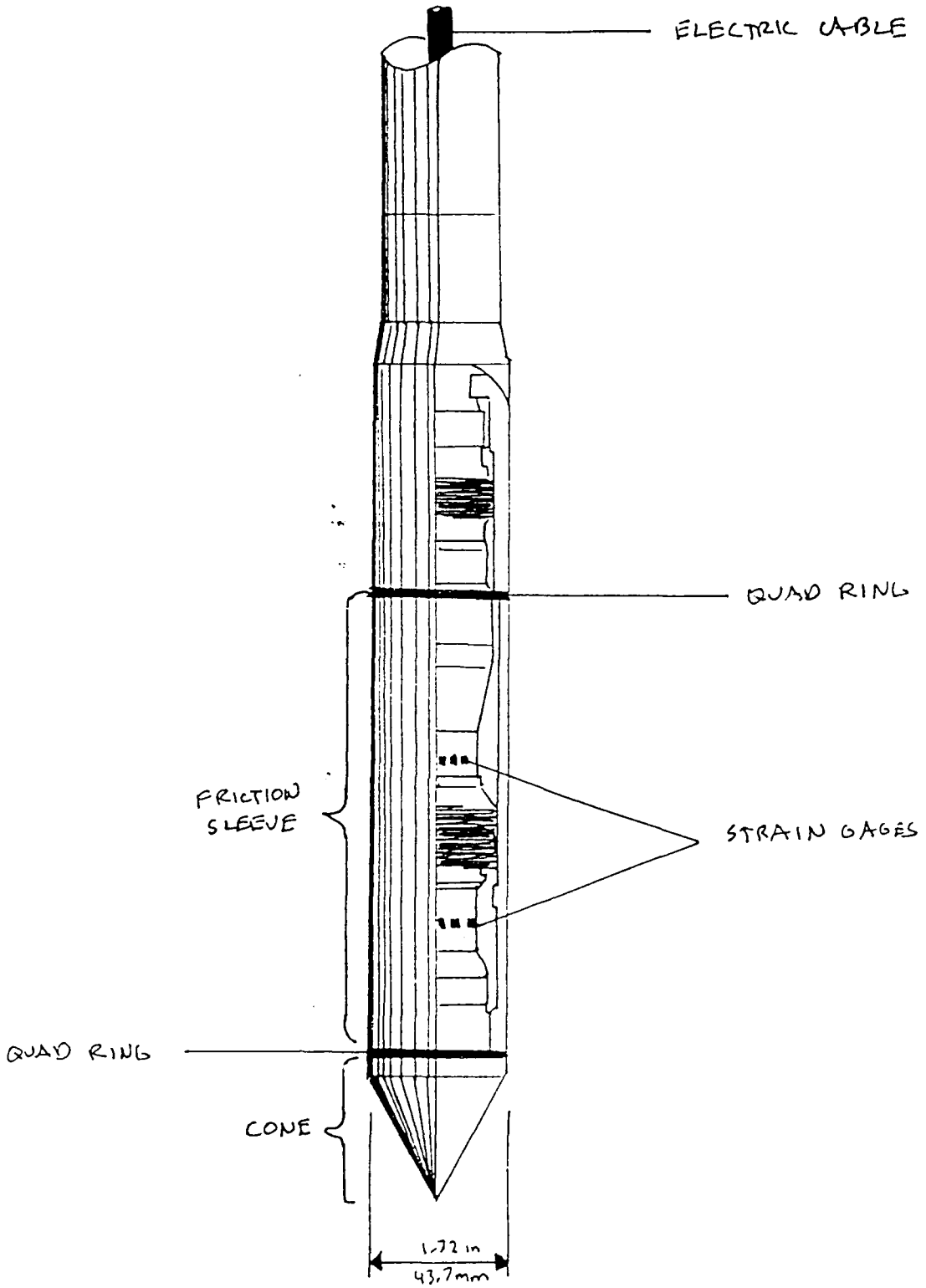
The CPT truck is shown is Figure 1. The 20 ton capacity CPT truck contained all the equipment needed for a large-scale subsurface exploration effort. The essential equipment involved in the cone testing is shown located within the CPT truck. Figure 2 displays an internal and outer view of the conventional instrument. Outside features which are shown are the cone tip, friction sleeve, quad rings, and the electric cable leading back to the truck. A rough representation of the strain gauges inside the probe is also displayed.

The diameter of the cone tip is 4.37 cm. The projected area of the cone tip is 15 cm^2. The apex angle of the cone tip is 60 degrees. The diameter of the friction sleeve is also 4.37 cm. The friction sleeve has a surface area of about 200 cm^2.



20 TON CAPACITY CPT TRUCK

FIGURE 1



IS TON ELECTRIC FRICTION CONE INSTRUMENT

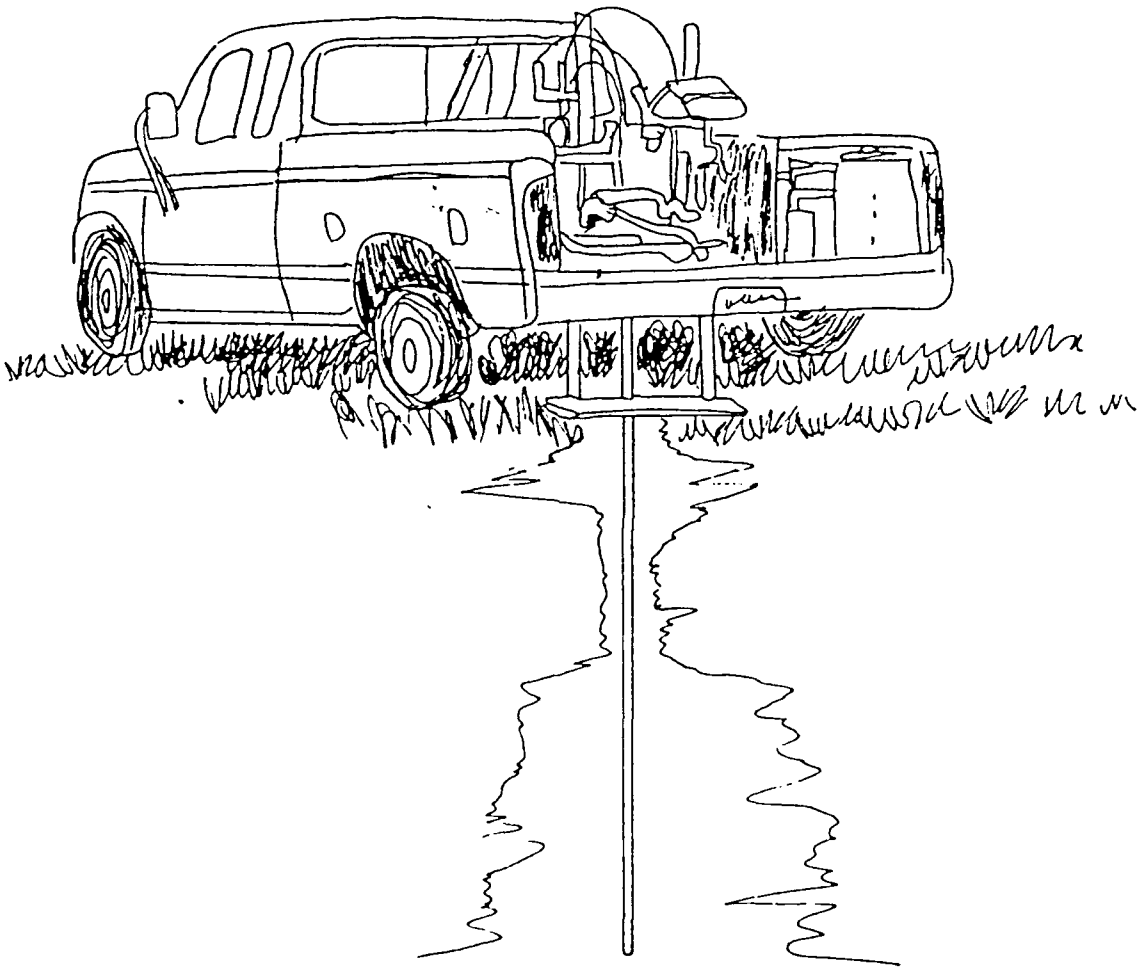
FIGURE 2

2.2 MINIATURE CONE PENETROMETER

The miniature cone penetrometer is commonly referred to as the minicone. The miniature cone penetrometer tests (MCPT) were performed in small intervals to produce very specific information about the near subsurface of the test site. The minicone is a 1.5 ton capacity instrument. A four ton pick-up truck system was used to deploy the minicone (Figure 3). Figure 4 displays the minicone and the important parts associated with the cone. The minicone is primarily used for shallow subsurface penetrations or for difficult to access areas.

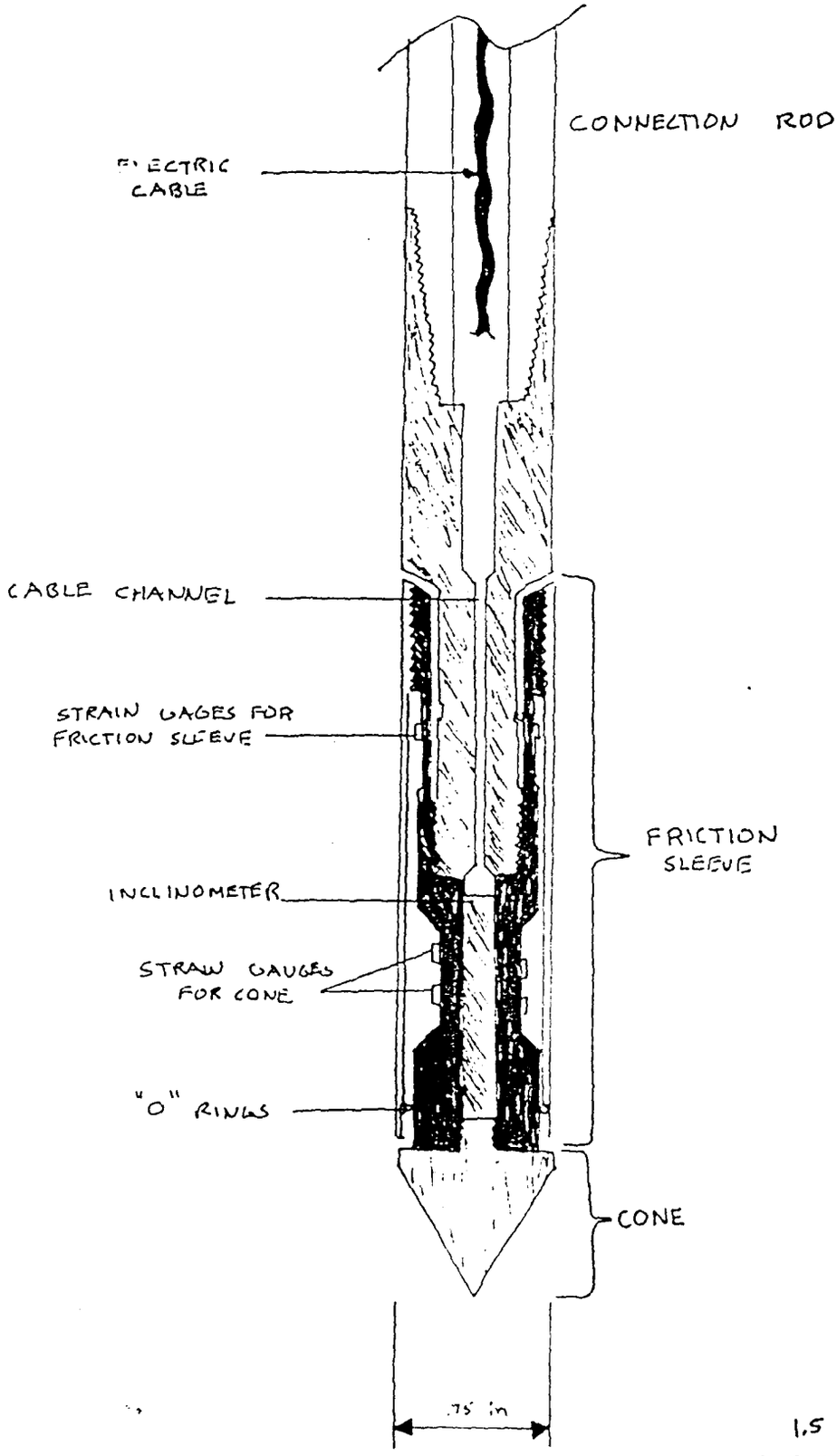
Basically, the same procedure was followed in the MCPT tests as in the conventional testing. However, the testing was conducted on a much smaller scale. The minicone is extensively equipped with strain gauges. As in the conventional ional cone, the gauges allow simultaneous measurements during penetration.

The minicone has a cone diameter of 1.9 cm. The projected area is 2.84 cm^2. The apex angle of the cone tip is 60 degrees. The diameter of the friction sleeve is also 1.9 cm. The surface area of the friction sleeve is 36.39 cm^2.



A TON CAPACITY
(MINICONE) TRUCK
MCPT

FIGURE 3



1.5 TON CAPACITY INSTRUMENT (MINICONE)

FIGURE 4

2.3 CRAPS EXPERIMENTS

The cone penetrometer data used in this report was part of a major experimental test designated CRAPS. The CRAPS test series was conducted to further understand the relationship between the random variability in the subsurface and explosively induced ground motions and wave propagation. CRAPS stands for Coherence for Range and Array ParameterS. Conducted in 1988, the test consisted of four, 100 pound detonations. These detonations occured in sequence on top of the same test bed.

A considerable subsurface exploration effort was undertaken prior to the explosive tests. The subsurface tests were conducted to obtain information relating to the heterogeneity and variability of the subsurface. The exploration tests included the cone penetrometer testing, drilling and sampling, and seismic surveys. This report focuses on the results of the cone penetrometer testing.

The results from the CRAPS tests revealed a considerable amount of scattering in ground motion data. The CRAPS experiment solidified the concept that the resulting scatter in ground motion data was a result of geologic inhomogeneity. The exploration effort was designed to help in fully understanding the

relationship between the variations and the subsurface soil material.

2.4 SITE INVESTIGATION LAYOUT

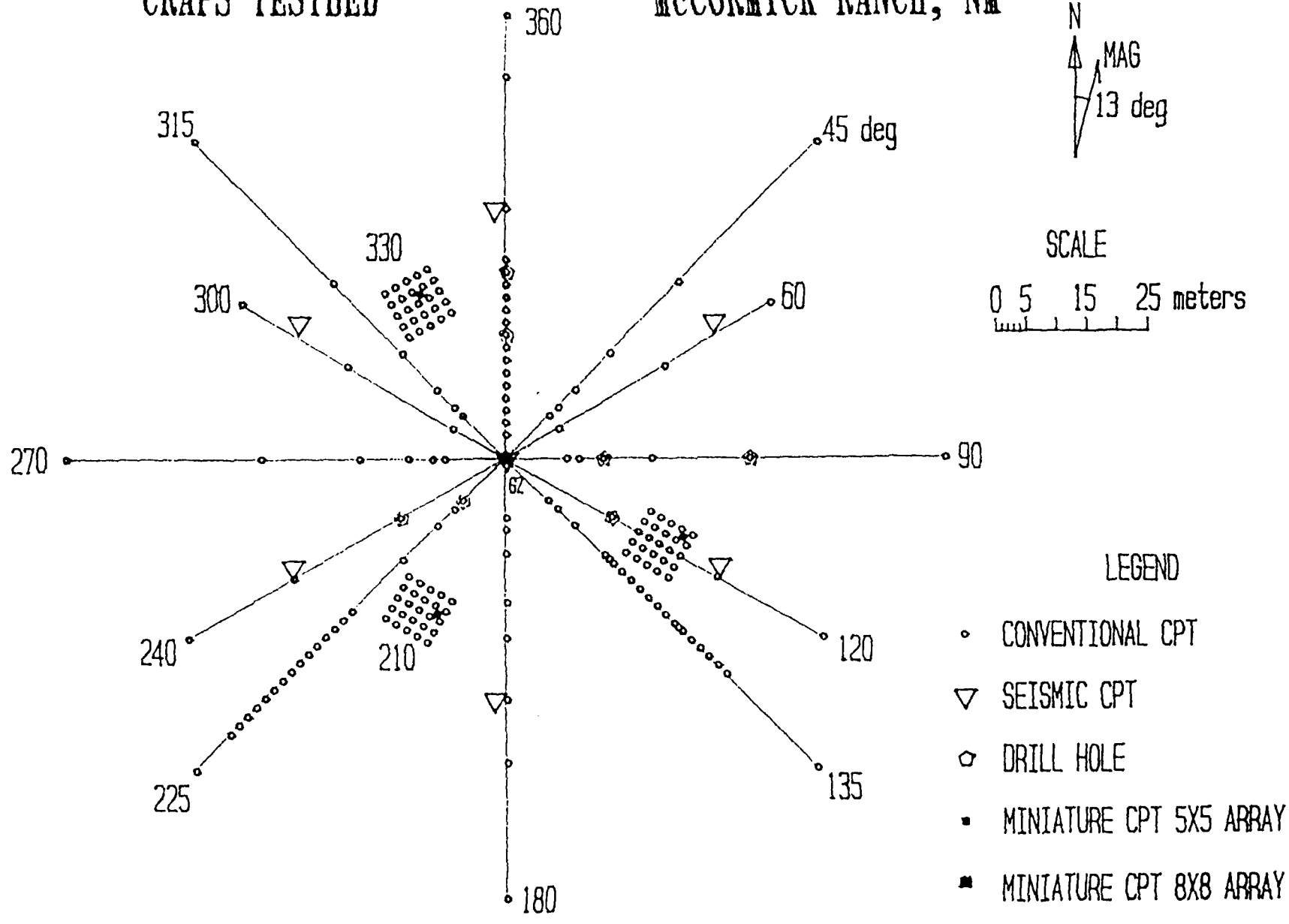
The layout of the cone penetrometer tests had two goals. One was to obtain a general description of the shallow subsurface. The other was to acquire detailed statistical descriptions of the subsurface in selected areas. Figure 5 shows the CRAPS testbed and the location of the cone penetrometer soundings. The layout includes a series of azimuthal arrays. Also included are specified arrays of five or eight soundings.

There were six large arrays used to determine a general description of the geologic media. The four major arrays designated by their azimuthal directions are 45/225, 90/270, 135/315, and 180/360. The same pattern and interval spacing are used in these particular arrays. However, on one side of three arrays there is a concentration of conventional cone soundings. These soundings were equally spaced to obtain statistical information regarding the soil below. The remaining arrays are 60/240 and 120/300.

Three 5 X 5 array blocks using the conventional cone

were constructed. These arrays are 120, 210, and 330. The objective was to again obtain a detailed description of the geologic media from all directions of the test site at GZ (Ground Zero). The interval spacing between all of the cone soundings was two meters.

The minicone tests were conducted at four locations. The locations include GZ, 120, 210, and 330. All of the minicone test except GZ were conducted within the conventional cone arrays. The minicone did not penetrate as deep as the conventional cone. However, the sample intervals were much closer together. This facet enabled the minicone to obtain highly detailed stratigraphic information about the near subsurface. The GZ minicone tests were conducted in 8 X 8 arrays. The remaining minicone tests were in 5 X 5 arrays. The minicone has an interval spacing of .2 meters. The layout of the arrays and soundings provided the Air Force Weapons Laboratory with substantial information regarding the geologic makeup of the CRAPS testbed.



127-15

FIGURE 5

2.5 DATA REDUCTION AND INTERPRETATION

The data obtained from the cone penetrometer tests were imported to the Earth Technology Corporation computer located on the CPT truck. The computer system was capable of producing immediate plots of cone tip pressure, friction sleeve resistence, and friction ratio. The system also tabulated data at certain predetermined intervals. These tabulations include normalized cone tip resistence, friction sleeve resistence, friction ratio, and soil behavior types. Besides providing on the spot results, the data received from testing was immediately digitized and stored in the computer memory. The stratigraphic information acquired from the cone penetrometer tests displayed results with good vertical resolution. The friction ratio was used as a main indicator of several soil type characterizations. Soil materials produced different resistence measurements and friction ratio results. By using these results parameters were established. These parameters enhanced our knowledge of the makeup of the subsurface.

2.6 OVERBURDEN PRESSURE

The initial data taken from the the Qc is not an accurate representation of the resistence levels. As the cone penetrates deeper the data recorded is altered at a consistent rate. This is due to the overburden pressure. The overburden pressure is the weight of soil material added to the pressure in the subsurface. When the penetrometer contacts the material the cone measures the resistence and also the added pressure from the material above. An equation was derived that counteracts this (Ref. 1). The overburden normalizing equation is shown below. Also shown are measurements for TSF (tons per sq. foot) and a description of the variables in the normalizing equation.

$$Qcl = Qc * Cn \quad (1)$$

$$Qcl = Qc * (1 - \log v\ \sigma') \quad (2)$$

Qcl = is the overburden normalized cone resistence; in TSF
Qc = is the measured cone tip resistence; in TSF
Cn = is the overburden correction factor
v = is the effective vertical overburden stress; in TSF

1 TSF = 0.976 kg/cm^2

1 kg/cm^2 = 1.025 TSF

2.7 PRIOR RESEARCH

TOPOGRAPHIC CROSS-SECTION OF SUBSURFACE

Prior to this project I conducted extensive research regarding the characterization of subsurface materials using the same cone penetrometer data. The objective of this research was to produce a topographic cross-section view of the subsurface. All the soundings in each array were run through programs that would eventually alter the data so that it would be compatible with a contouring software program.

Several informative cross-sections were produced. These plots provided essential information on the geologic media of the test site. The 180/360 conventional cone array cross-section is shown if Figure 6 (Ref. 3). The X axis is the range of the entire array in meters. The Y axis is the depth in meters. The Z axis is the cone tip pressure measurement. The vertical blue lines represent the locations of all the soundings on the array. The vertical lines also illustrate how deep an individual cone penetrated compared to others. Every 25 TSF is labeled and the contour interval was 5 TSF. There were a total of 19 soundings used in this particular cross-section.

The plot provides a remarkable view of the layering and scattering of soil properties. Special interest was given to the

part of the plot which has a higher concentration of cone soundings. The contours shown for the geology between the 42 and 72 meter range on either side of GZ should not be taken as accurate results. Additionally, the area below the six meter mark in depth should also be considered as a correct representation of the subsurface. The data for the above mentioned areas was quite limited and was primarily the production of guesswork by a computer contouring program. However, the middle region should be taken as an accurate representation of the soil materials below the ground at that location.

The topographic cross-section displays a significant amount of layering. A soft topsoil layer rests above a heavily consolidated layer of caliche. Below the caliche layer are various layers of possibly clay and silt. The cross-section provided a visual view of the inhomogeneity of the subsurface in general and also in individual layers of soil.

CONE TIP PRESSURE 180/360

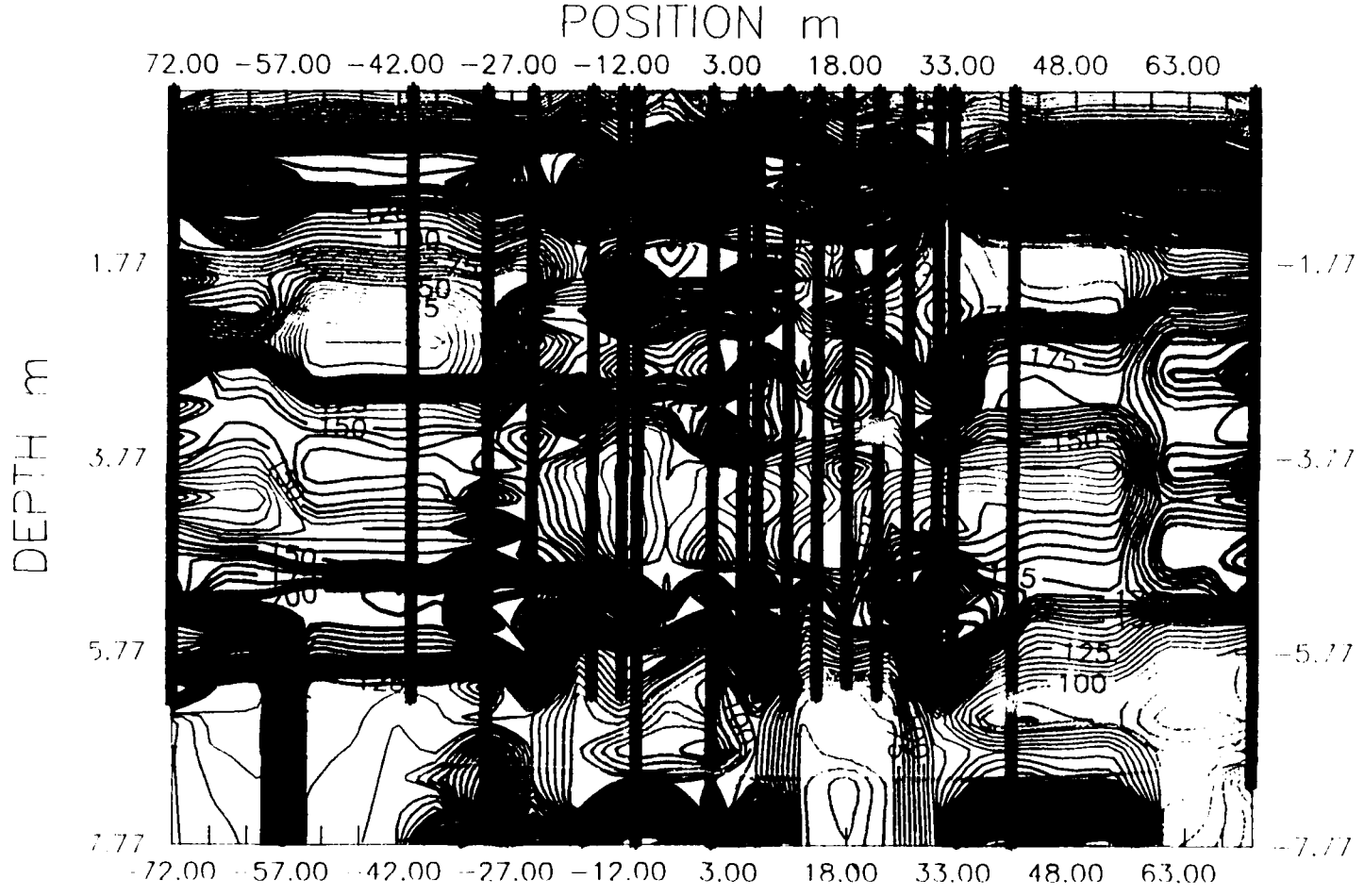


FIGURE 6

3.0 STATISTICAL ANALYSIS

The purpose of my research was to analyze the existing cone data in a statistical fashion. This was done to quantify the subsurface variability in a statistical manner. The methods used were calculations of arithmetic mean and standard deviation, and also the utilization of histogram plots. Prior research on the production of actual visual representation of the data were also included to provide additional results regarding the cone penetrometer tests. The use of the arithmetic mean and standard helped establish definite conclusions on the behavior patterns of geologic media. The histogram were used primarily to determine if any possible universal behavior patterns of soil or soil layers exist. A combination of different computer software programs were also utilized to attain acceptable data to work with.

3.1 COMPUTER PROGRAMS

Several software programs were utilized to attain a statistical analysis of the cone penetrometer data. Those programs included BASIC, Sigmaplot, and Surfer. BASIC was used to write programs that altered the data and performed mathematical computations. Sigmaplot was used to plot the histograms. The Surfer program was used to make the cross-section graphs.

The first program in BASIC changed the original data file so that it was compatible with the other software programs. The Surfer program requires the data to be in three column form (X,Y,Z). The X axis is the range in meters. The Y axis is the depth in meters. The Z axis represents the measurements column. The depth column was converted from feet to meters in order to correspond with the range. All of the output files in one array were stacked on one another. This process allows Surfer to create a topographic cross-section of the subsurface.

The arithmetic mean and standard deviation for each sounding was calculated using a program written in BASIC. The program isolates the desired measurement column. The data is inserted into a loop that adds all the measurements together. The sum is then divided by the total number of measurements. The

data file and the mean are then used in the computation of the standard deviation. In order to obtain a data file for the histogram the data file had to be run through another program. The program counts the number of samples for a specified interval and subsequently produces an output file compatible with Sigmaplot.

Sigmaplot merely takes data files in column form and then plots them according to what form best suits the user. The Surfer program is able to make high resolution graphs, both two and three dimensional. The Surfer program has a series of menus designed to guide the user. The program provides the user with hundreds of options for making contour maps and surface plots. Different menus in the program include GRID, TOPO, SURF, and PLOT. The GRID menu takes irregularly spaced data and makes a regularly spaced grid. The TOPO menu allows the user to make contour maps.

3.2 ARITHMETIC MEAN AND STANDARD DEVIATION

The statistical analysis of the cone penetrometer data was performed using the equations for the arithmetic mean and standard deviation. The mean (μ) and standard deviation (σ) are commonly used in analyzing all forms of experimental data and results. A normal distribution curve is produced with the use of these two equations. The equation for the arithmetic mean is shown below;

$$\bar{X} = (1/n) \sum_{i=1}^{n} Xi \qquad (3)$$

where $\bar{X}$ is the mean, Xi is the measured cone tip pressure at a specific interval depth, and N as the total number of data points in the file. In the conventional cone the N averaged 206 data points per sounding while the minicone was 125 data points per sounding. The arithmetic mean is the mode of a normal curve. The mode is the single highest point in the curve. It is also the median of the curve. Therefore, the arithmetic mean is the location parameter of a normal distribution curve. Consequently, any change occuring in the mean just moves the location of the curve and does not distort the actual shape of the curve itself.

(Figure 7). The mean plays an important role in analyzing the histograms of the conventional and minicone penetrometers.

The standard deviation is the distance from the mean to the two inflection points of the curve. The inflection point on a curve is the location where the curve converts from concave upward to concave downward. Standard deviation is merely a measure of scattering or dispersion in data. A change occuring in the standard deviation will change the general shape of the curve (Figure 8). The standard equation for σ is shown below;

$$\sigma = [\ (1/N) \sum_{i=1}^{n} (Xi-\bar{X})^2]^{1/2} \qquad (4)$$

where σ is the standard deviation, N is the number of data points in the individual file. Xi is the individual data point and $\bar{X}$ is the mean.

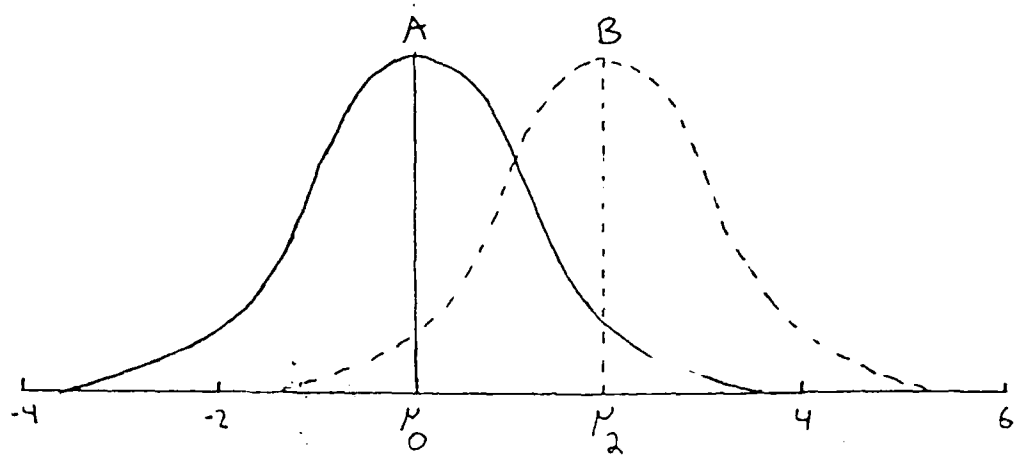


FIGURE 7 A) $\mu = 0, \sigma = 2$ B) $\mu = 2, \sigma = 2$

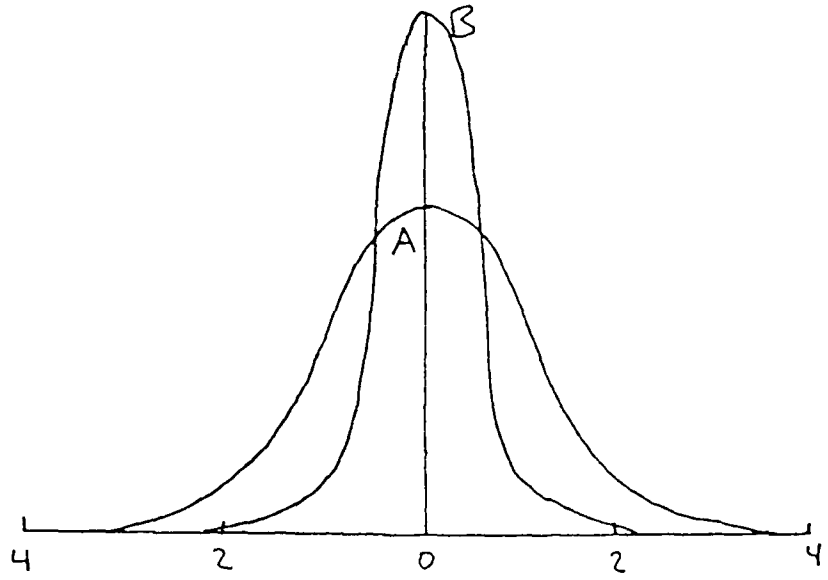


FIGURE 8 A) $\mu = 0, \sigma = 2$ B) $\mu = 0, \sigma = 1$

3.3 HISTOGRAMS

Histograms are excellent tools for defining certain characteristics of data. For the cone penetrometer they were especially beneficial in designating curves. These curves aid to establish a pattern of soil distribution in the geologic media. A main objective was to attempt to associate a specific distribution curve to the geologic media. The Gaussian distribution curve is a common one. The Gaussian curve is symmetrical and bell shaped. A normal curve is also unimodal. Figure 9 shows a computer generated model of three different types of random numbers placed in histogram form. The bell shaped Gaussian curve can easily be distinguished. The narrower one resembles an exponential distribution. The third set of numbers are just random points with no distinct curve associated with it. Figure 10 is a 2-D plot of the random numbers. The mean is centered at 75. The three different standard deviations are 25, 50 , and 75. Histograms display a informative but different perspective of the data.

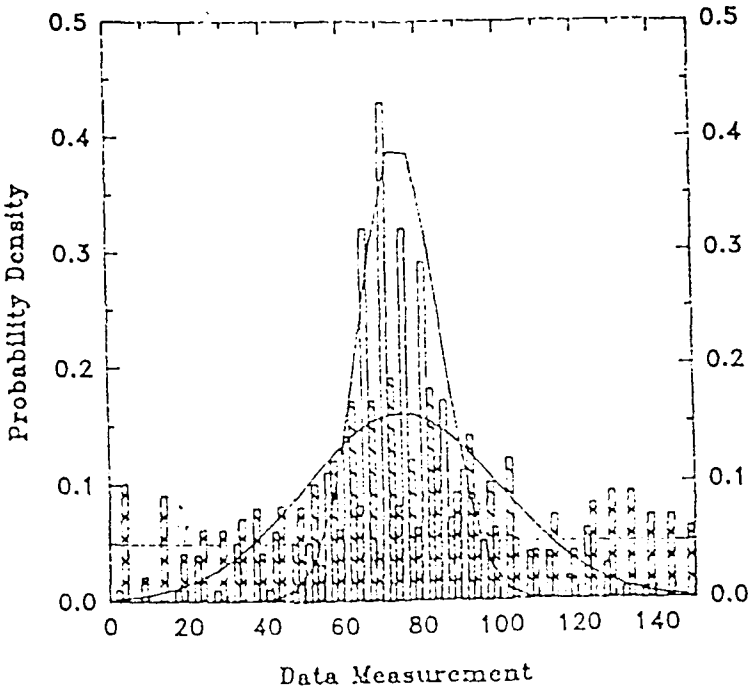
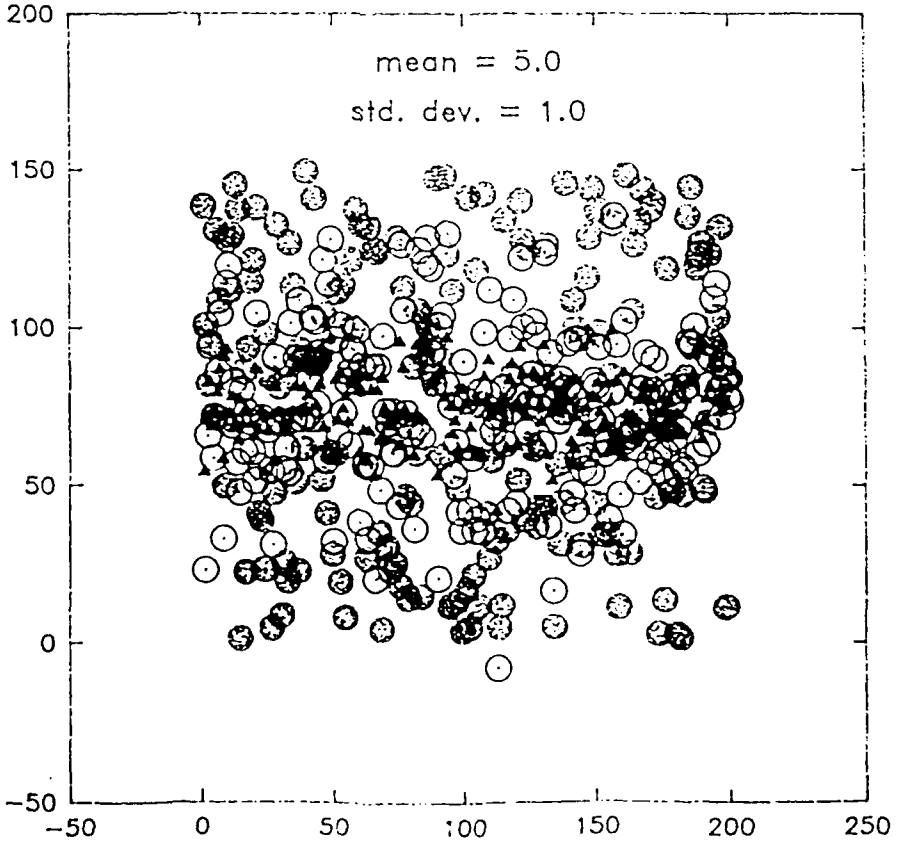

Probability Density
0.5
0.4
0.3
0.2
0.1
0.0
0
20
40
60
80
100
120
140
Data Measurement

FIGURE 9


mean = 5.0
std. dev. = 1.0
200
150
100
50
0
−50
−50
0
50
100
150
200
250

RESULTS

4.0 MEAN AND STANDARD DEVIATION CONVENTIONAL CONE DATA

The calculated means and standard deviations of the conventional cone penetrometer data revealed some significant results. Table 1 shows the cone tip pressure mean, standard deviation in TSF, and the standard deviation in percent. Each array includes approximately 15 soundings each. The 5 X 5 arrays (2D) contained 25 soundings each. Each line of the table represents the average results for the particular series.

The mean of all the conventional cone soundings was 141 TSF. The maximum was 166 TSF and the minimum was 127 TSF. The average standard deviation in TSF was nearly 59. The maximum and minimum TSF deviations were 69 and 49 respectively. The percent of deviation was 41.6%. The maximum was only 44% with a minimum of 38%. The consistent standard deviation data reveal very specific results about the condition of the subsurface.

A major result of the deviations are the considerably high deviation readings. These results show that the geologic media has a high degree of inhomogeneity. A homogeneous subsurface would usually have a significantly lower deviation. However, the consistency of the deviations also reveals another

interesting aspect. It shows that the statistical characteristics of the variability and inhomogeneity of the subsurface at McCormick Ranch has a clear condition of stationarity. Stationarity states that the variations discovered were fairly uniform throughout the region tested.

TABLE I

CONVENTIONAL CONE PENETROMETER TESTS
CONE TIP PRESSURE

LOCATION	μ	σ	%
ARRAY 45/225	136.204	56.761	± 41.7
ARRAY 90/270	154.385	61.270	± 39.7
ARRAY 135/315	149.682	60.555	± 40.5
ARRAY 180/360	139.782	61.911	± 44.3
2D120	166.791	69.645	± 41.8
2D210	127.403	54.673	± 43.0
2D330	128.147	49.241	± 38.4
TOTAL AVERAGE	141.588	58.969	± 41.6

4.1 MEAN AND STANDARD DEVIATION FOR MINICONE

The minicone calculations for arithmethic mean and standard deviation were very different from the conventional cone results. Table 2 shows the results for ground zero. Each array shown contains eight soundings. The average mean was 137 with a standard deviation of 59.5%. There was a high of 61.1% and a low of 56.8%. The results here are different in that the variability was 50% higher the conventional cone penetrometer. The very high variability shows that the subsurface has a high degree of inhomogeneity. However, they are similar in that the percentages do not differ greatly. This points out that the shallow subsurface contains the same level of variability in all directions. Table 3 displays minicone 5 X 5 block MC120. It had a high mean of 162 with 64.3% standard deviation. Table 4 shows the calculations for MC210. MC210 had a very low mean of 76 and standard deviation of 42.4%. By contrasting cross-sections of the MC210 block it was discovered that the caliche layer was absent from this particular location. Table 5 shows the calculation for MC330. MC330 had a mean of 124 and deviation of 53.1%. The results from the minicone establish the existence of a hard consolidated soil layer near the surface and the extreme inhomogeneity of the test site.

TABLE 2

GROUND ZERO

LOCATION	μ	σ	%
MCGZA	117.714	66.812	56.8
MCGZB	134.299	80.577	60.0
MCGZC	137.198	80.266	58.5
MCGZD	143.473	87.091	60.7
MCGZE	139.253	83.236	59.8
MCGZF	137.299	81.029	59.0
MCGZG	137.887	84.191	61.1
MCGZH	150.699	90.112	59.8
AVERAGE	137.187	81.637	59.5

TABLE 3

MC120

LOCATION	μ	σ	%
MC120A	121.794	90.337	74.2
MC120B	157.885	104.532	66.2
MC120C	178.361	115.988	65.0
MC120D	183.020	112.030	61.2
MC120E	173.040	100.789	58.2
AVERAGE	162.820	104.729	64.3

TABLE 4

MC210

LOCATION	μ	σ	%
MC210A	66.715	26.080	39.1
MC210B	73.716	28.299	38.4
MC210C	70.695	27.907	39.5
MC210D	79.912	30.550	38.2
MC210E	88.842	46.843	52.7
TOTAL AVERAGE	76.070	32.232	42.4

TABLE 5

MC330

LOCATION	μ	σ	%
MC330A	124.296	65.075	52.4
MC330B	123.540	67.409	54.6
MC330C	117.079	71.866	61.4
MC330D	133.720	71.169	53.2
MC330E	123.260	54.774	44.4
TOTAL AVERAGE	124.379	66.059	53.1

4.2 CONVENTIONAL CONE HISTOGRAMS

The histograms for the conventional cone penetrometer revealed informative results on the condition of the subsurface. All the soundings in one array were combined to produce a single histogram. The X axis is the measured cone tip pressure at intervals of 10 TSF. The Y axis is the average number of samples per individual sounding. All the histograms had a unimodal form. Unimodal refers to the curve having a single high point.

Figure 11 shows the 45/225 array. It had a peak of 15 average samples at mean 140. However, the two sides of the curve are visibly different from each other. A significant rise in the 60-70 TSF range was also discovered in the left side of the curve. Array 90/270 (Fig. 12) displays a more symmetrical curve. The distribution curve resembles the Gaussian in some respects. Array 90/270 had a peak of 19 average samples at 140 TSF. However, 90/270 had almost half as many soundings as the rest of the arrays. Figure 13 displays array 135/315. It had a peak of 16 average samples at 160 TSF. Array 135/315 was the only array with a different mean. This can be attributed to a larger layer of consolidated material than most other locations. An example of skewness was also observed. Array 180/360 (Fig. 14) displayed a definite example of extreme skewness. The right side

of the curve resembles an exponential distribution. The peak was 19 average samples at mean 140 TSF.

All of the 144 long conventional cone arrays were averaged together to produce the histogram in figure 15. An immediate observation was the skewness associated with the left side of the distribution curve. There could be a higher concentration of softer soil in the 50-100 TSF range. A possible explanation could also be the existence of two means. The second mean was reduced when all of the soundings were averaged together. This leads to the assumption that even though it is a unimodal histogram it really represent bimodal data results. The right side of the curve resembles the exponential curve of distribution. The different profiles of curve also lead to the assumption that there are two standard deviations for the curve. These discoveries again point out the inhomogeneity of the subsurface itself. However, a distinguishable curve was seen in all of the histograms. With the exception of 90/270 all the curves were almost identical. Therefore, there is a pattern in the distribution but it does not have the characteristics of an established distribution curve.

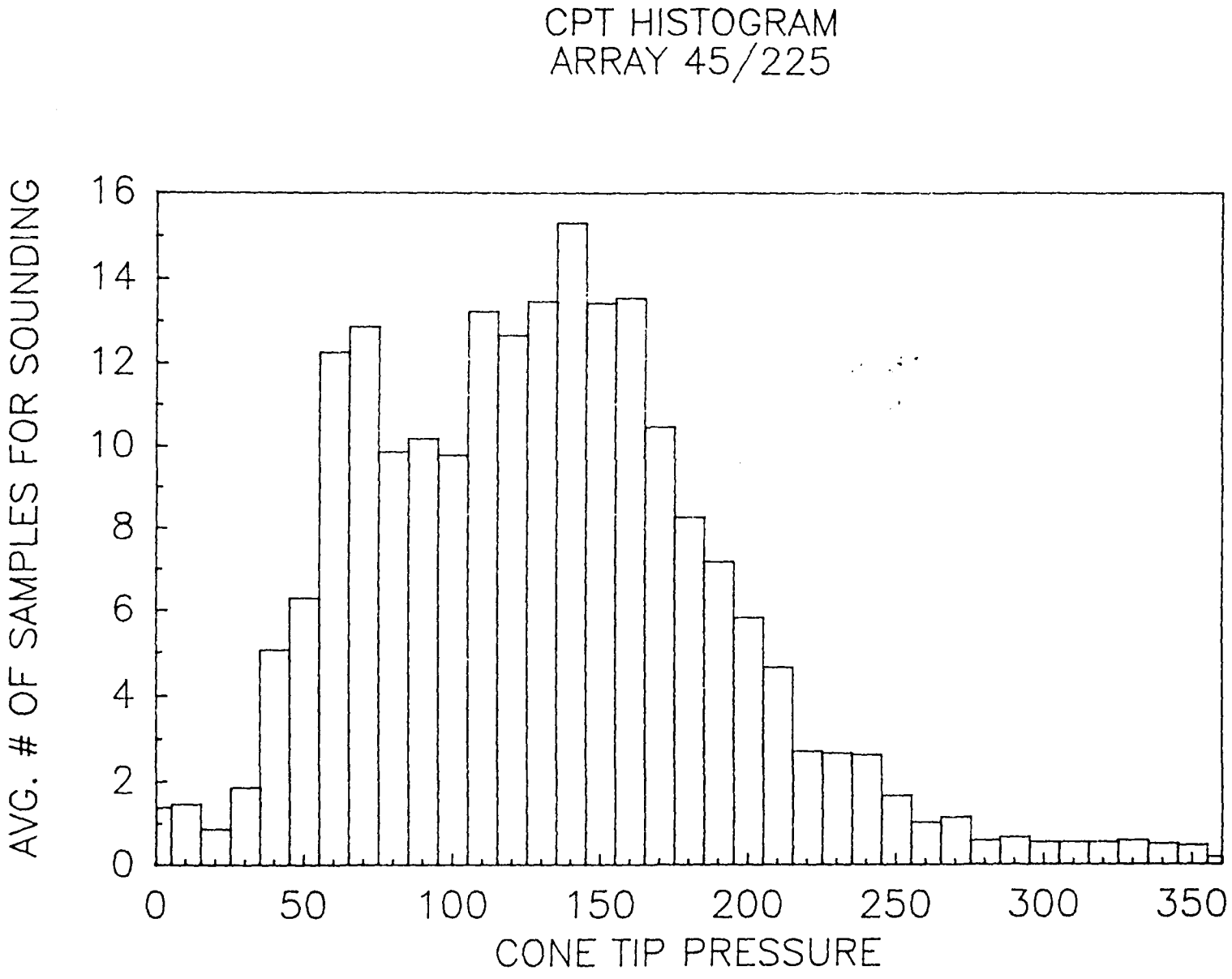

CPT HISTOGRAM
ARRAY 45/225
AVG. # OF SAMPLES FOR SOUNDING
0
2
4
6
8
10
12
14
16
0
50
100
150
200
250
300
350
CONE TIP PRESSURE

FIGURE 11

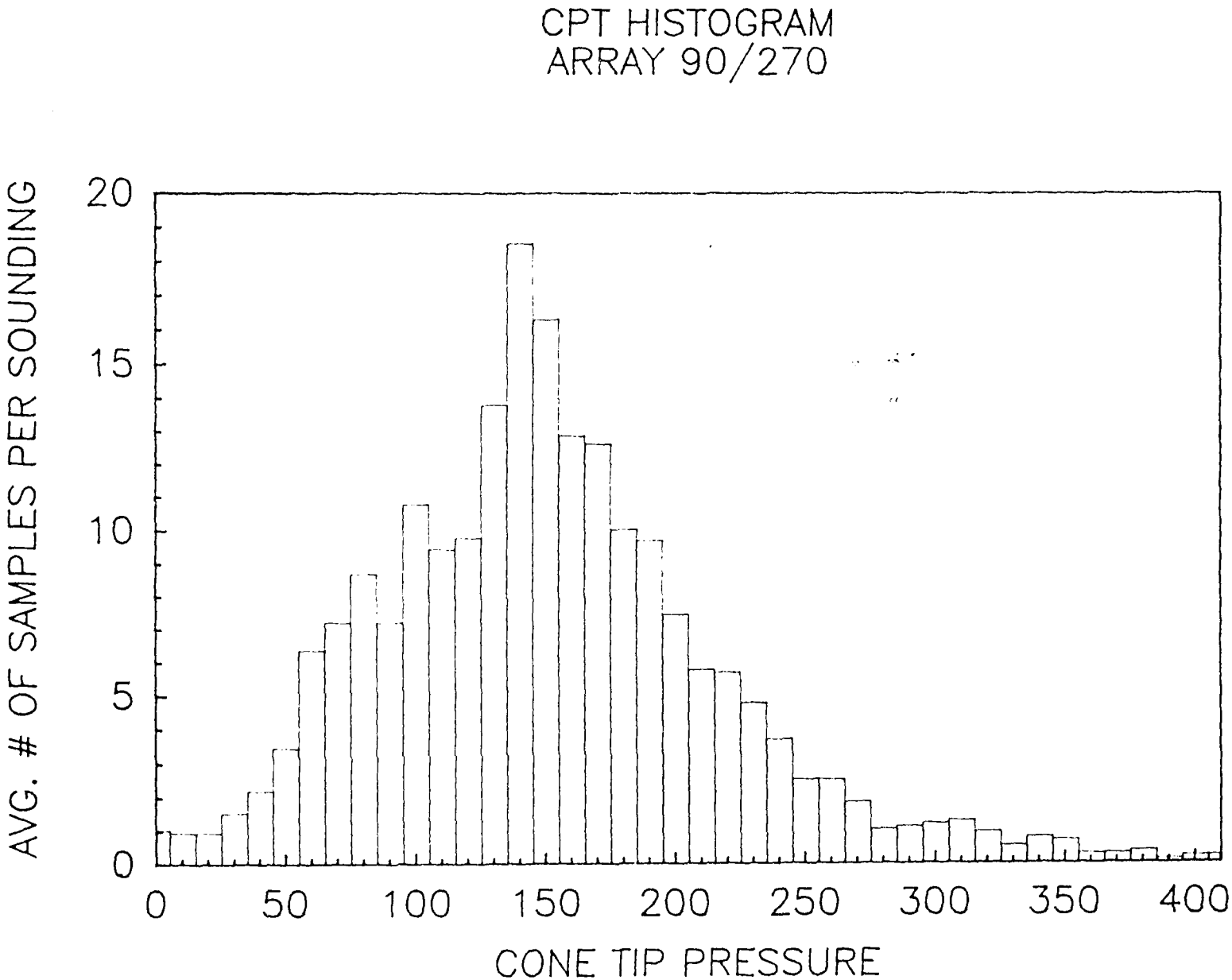
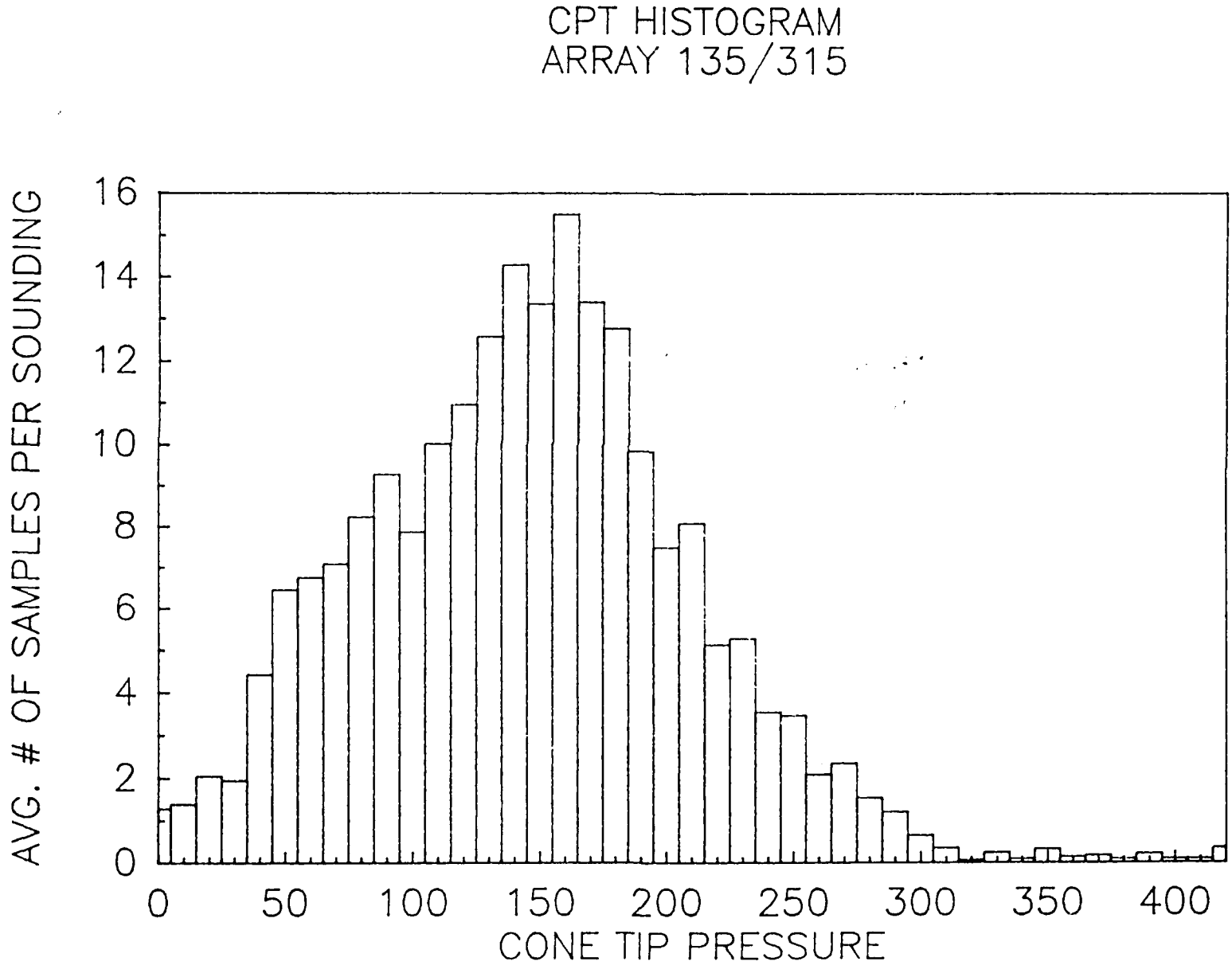
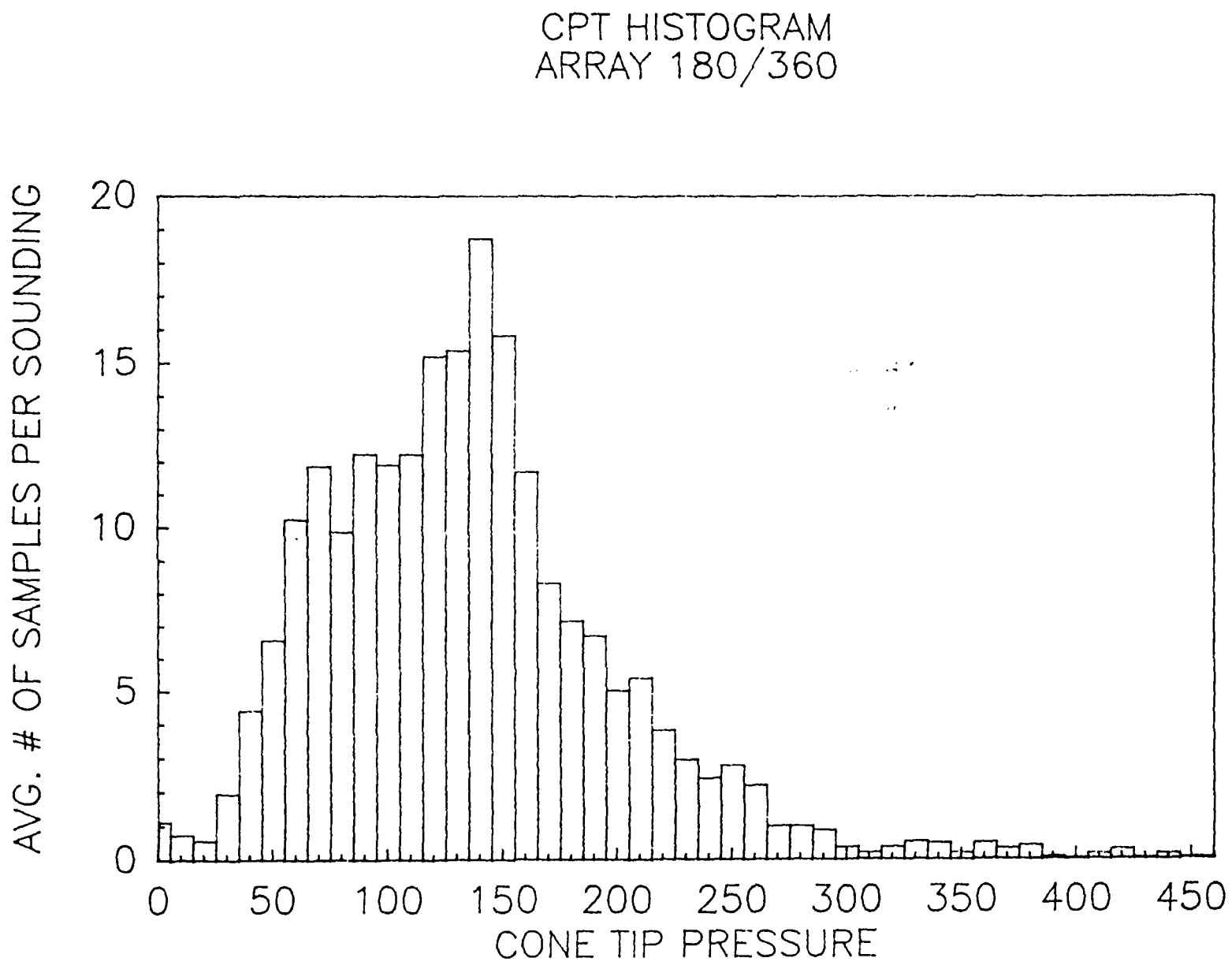
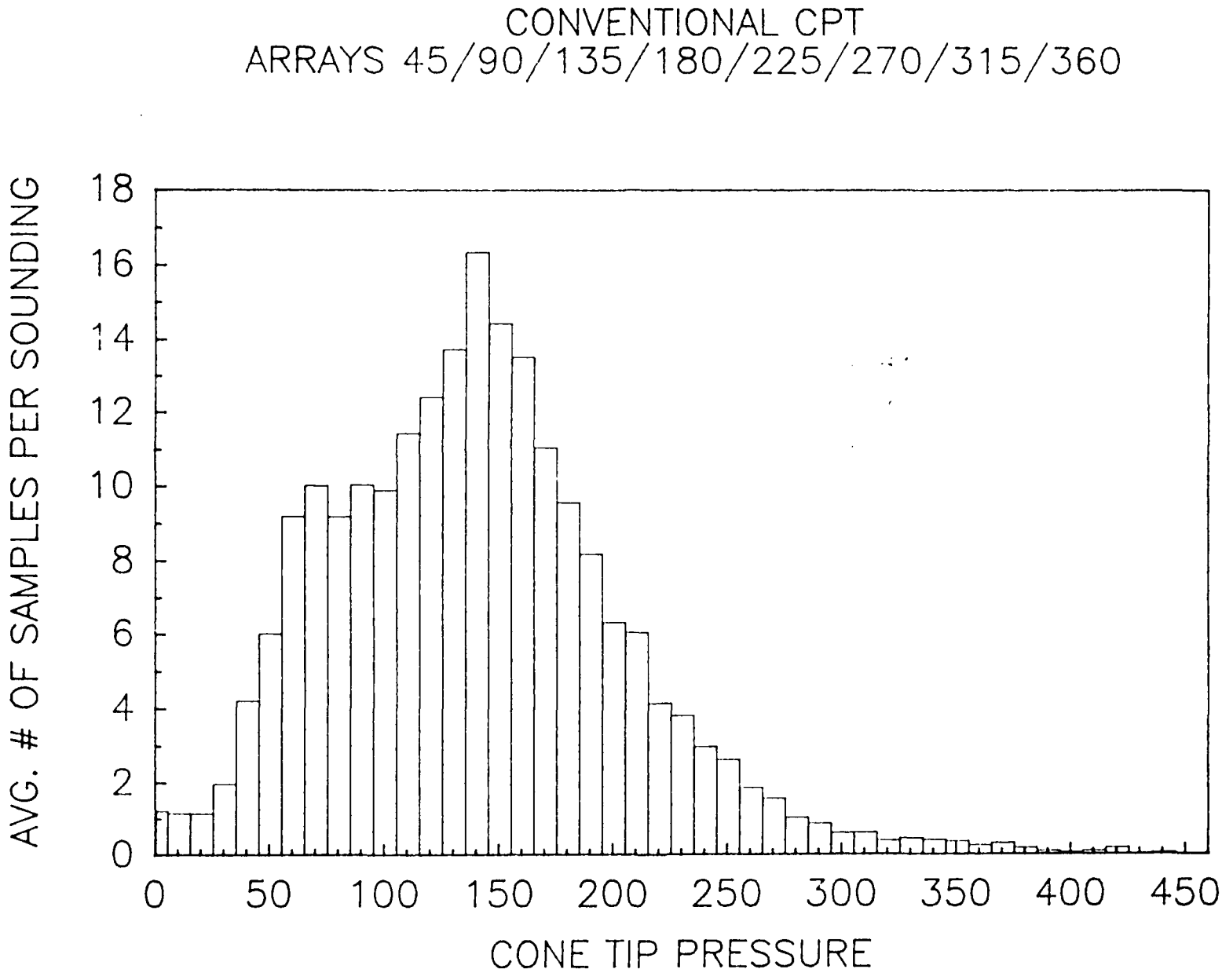

CPT HISTOGRAM
ARRAY 90/270
AVG. # OF SAMPLES PER SOUNDING
20
15
10
5
0
0
50
100
150
200
250
300
350
400
CONE TIP PRESSURE

Figure 12


CPT HISTOGRAM
ARRAY 135/315
AVG. # OF SAMPLES PER SOUNDING
0
2
4
6
8
10
12
14
16
0
50
100
150
200
250
300
350
400
CONE TIP PRESSURE

FIGURE


CPT HISTOGRAM
ARRAY 180/360
AVG. # OF SAMPLES PER SOUNDING
0
5
10
15
20
0
50
100
150
200
250
300
350
400
450
CONE TIP PRESSURE


CONVENTIONAL CPT
ARRAYS 45/90/135/180/225/270/315/360
AVG. # OF SAMPLES PER SOUNDING
0
2
4
6
8
10
12
14
16
18
0
50
100
150
200
250
300
350
400
450
CONE TIP PRESSURE

4.3 MINICONE HISTOGRAM
GROUND ZERO

The minicone histograms are substantially different from the conventional cone histograms. A major reason for the difference can be attributed to the standard deviations of the two cones. The minicone had very high standard deviations compared to the conventional. Figure 16 is the histogram of all the soundings at ground zero. There were a total of 63 soundings involved in this histogram (one sounding contained bad data). The histogram displays the total number of samples of cone tip pressure at intervals of ten TSF.

The minicone penetrated to an average depth of 1.5 meters. The interval spacing between each one was 1.27 cm. The highest recorded measurement was 360 TSF. The arithmetic mean was 137.187 and the standard deviation was 59.5% (Table 2).

The minicone cross-sections already revealed the presence of two layers of soil. The top layer was regular topsoil and the second layer was caliche. The histogram clearly shows the two layers also with the bimodal curve. There are two different maximums for the subsurface materials. This would account for the extremly high standard deviations. When the two layers are averaged in, the mean is actually the low point on the

histogram.

The top layer had a mean of approximately 50 TSF. The distribution of the layer resembles the Gaussian curve. The TSF range for the topsoil spread from 0 to 100 TSF. The high curve seems to indicate that the topsoil has a higher amount of samples than the caliche. However, the TSF range is smaller than the caliche, which is more scattered. The top layer has a low amount of variability. The caliche layer displays a high amount of variability. The caliche layer also resembles a normal distribution curve. The caliche layer had a mean of 190 TSF. The minicone histograms show a resemblance to normal Gaussian distribution curves for two separate layers of soil.

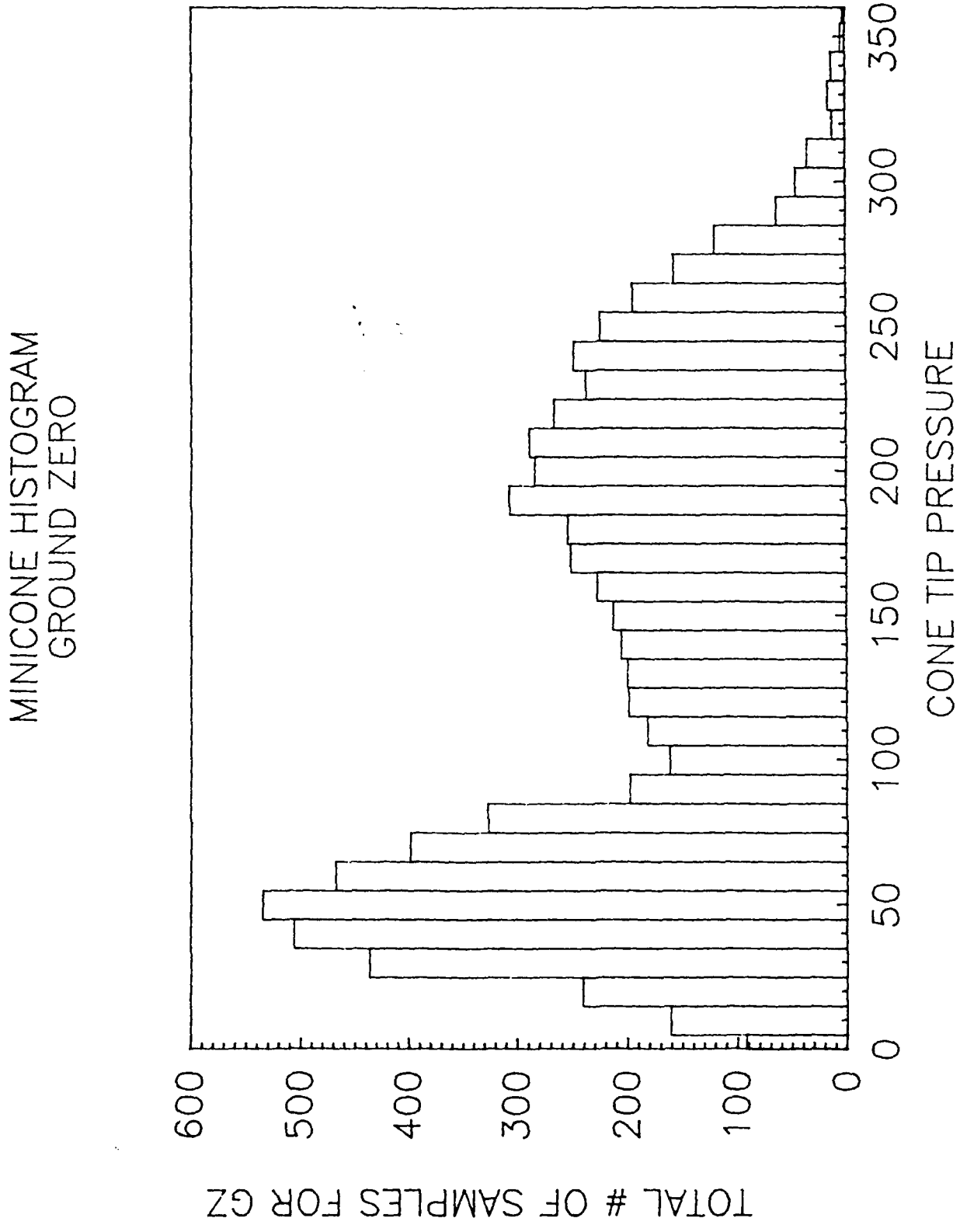

MINICONE HISTOGRAM
GROUND ZERO
TOTAL # OF SAMPLES FOR GZ
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
CONE TIP PRESSURE

FIGURE 16

6.0 CONCLUSIONS

1) The topographic cross-sections show that the geologic media at the test site contain several layers of different soils. The cross-sections also show the inhomogeneity of the subsurface.

2) There is a hard consolidated layer of caliche at = .5 m depth throughout the entire test bed (with the exception of the MC210).

3) The m and s values for the cone penetrometer show that the there is considerable variability in the subsurface materials. The variability is consistent throughout the entire testbed.

4) The geology does not produce unimodal results. There are two means for the geology in most arrays.

5) There are two different standard deviations for the geology. There are different levels of variability for different layers of soil.

6) The general geology follows a skewed distribution curve.

7) The different variability levels in each individual layer could present a problem in modeling the subsurface. A layered model with different levels of variability for each layer could better define the paths of wave propagation than general unlayered model of geology.

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Ryan McAlhaney

Final Report Number 128

No Report Submitted

MICROWAVE SUSCEPTIBILITY TESTING OF MICRO-CIRCUITRY

A FINAL REPORT

PRESENTED
BY

MARGARET MORECOCK

WEAPONS LABORATORY
KIRTLAND AIR FORCE BASE

FOR

UNIVERSAL ENERGY SYSTEMS

AUGUST 13, 1990

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INTRODUCTION

I found my summer job at the Kirtland Air Force Base Weapons Lab to be very enjoyable and educational. Working in a scientific atmosphere exposed me to some of the ups and downs that come with scientific research. It enabled me to work with advanced equipment and learn of current research in the Air Force.

Though my report covers only the work I did on a circuit, I also did various tasks within my section. I did a great deal of library research on B-dot and D-dot probes and the anechoic chamber. I then helped finish a 17 by 12 foot chamber in our laboratory, designed for low power microwave testing. I also made four different programs to aid in data collecting for the flight control computer testing being done in section 909's high power microwave chamber. Then I worked with Ron and John on the Rate Gyro, a pitch sensing device in the F-16.

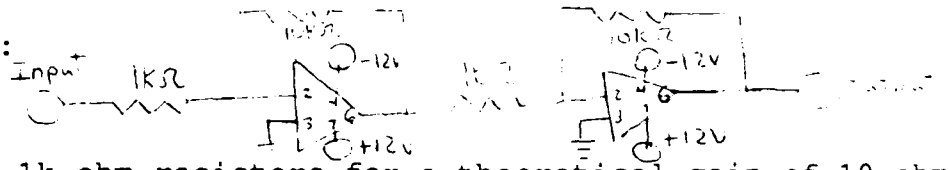
With these projects I learned how to gather research effectively, program in the C language, work with the equipment, and test the Rate Gyro, long with acquiring knowledge about the anechoic chamber, microwaves, and the future plans to test an F-16.

PROJECT: Microwave susceptibility testing of micro-circuitry

TEST PLAN: Begin by making a circuit with two LM741 or LM301 operational amplifiers in series. Then test it at low frequencies before running high frequency signals, or microwaves, through the circuit to test for any differences or reactions.

HYPOTHESIS: I guessed that the op. amps would simply be unable to deal with the higher frequencies because of their low bandwidth.

CIRCUIT DESIGN:

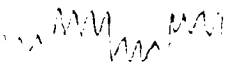
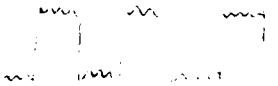
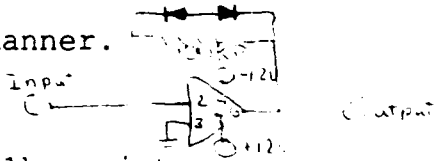


I used 10k and 1k ohm resistors for a theoretical gain of 10 ohms on each op amp for a combined total of 100 gain. My 12V power supply could not handle anything higher than a 12mV signal. I later replaced the 10k's with a 2k ohm and a 4k ohm resistor for a gain of 8.

EQUIPMENT: A Tektronix 2440 and a Tektronix 602 touch screen oscilloscope, a Hewlet Packard synthesized/wave generator, synthesized sweeper, a Fluke multimeter, a +/- 15 Volt and a +/- 12 Volt power supply.

SUPPLIES: A breadboard, three LM741CN, two LM301AN operational amplifiers, two each of 1k, 10k, 2k, 4k, four 100 ohm resistors, two 3.3V 1 watt zener diodes, four capacitors, jumper wires, coaxial cables, a modulator, adder, and multiplier devices.

TESTING: When I had my circuit working correctly with a 1V, 800 to 1000 Hz signal, and an output of 8V, I injected a microwave signal. I used the same 1V signal at a frequency of 1000 MHz and got an output of only 56mV. Next, my mentor helped me hook up a modulator

and multiplier to multiply the 1000 MHz signal with a 10 kHz square wave. Finally, we used the adder to make a signal that looked like this:  It consisted of the 1000 MHz sine wave riding on the lower frequency square wave. The output of the circuit was about 9V and looked like this:  In this case the microwave signal was screened out and almost ignored. Both the LM741's and the LM301's reacted in this manner. I also made a separate clipping amplifier circuit:  with two 3.3V zener diodes in series and 100k and 1k resistors on an LM741 op amp. The zener diodes reduce the gain of the amplifier if its output tries to exceed their limits which is a combined 7V. I tested the circuit with a 1V signal at 1000 Hz and then 1000 MHz. Again the microwave signal was ignored while the lower frequency worked correctly. I hooked this circuit into the previous one and the results were the same.

TROUBLE SHOOTING: I ran into the most difficulties with the equipment itself. It took a while to learn to use the synthesized sweepers, oscilloscopes, and the wave generator. I had to practice with the 2440 oscilloscope and the wave generator to learn how to correctly generate waves. This involved adjusting the correct variables on the screen and compensating for the impedance mismatch of the cable. Next I worked with the synthesizer/wave generator only to discover that it was incorrect. I would read a 1V signal from peak to peak when actually it would be a 2V signal p-p. Also, between 50 and 100mV the signal would be to large. For example at 99mV I would be getting a 3V signal! Then, when I switched to

100mV the signal would resume normalcy. Later, when I switched over to the higher frequency synthesized sweeper I had to convert the power supply from decibels per milliwatt to mV and volts with the formula listed below for a 50mV signal. Lastly I switched from the 15V to the 12V power supply because the 15V was unbalanced. I tried to compensate with a potentiometer strapped across the circuit but my mentor suggested I just get a different supply.
I also ran into circuit difficulties with "noise" or interference. I used four capacitors with 100 ohm resistors to smooth out the power supply only to discover later that they were unnecessary.
CONCLUSION: With both the adder and the multiplier signals the microwaves were ignored and the output of the low frequency wave mildly affected. When only the microwave signal was input then the output was almost nonexistent.

Converting decibels per milliwatt to millivolts

$$dB = 10 \log \frac{P_{out}}{P_{in}} \quad \text{where} \quad \frac{P_{out}}{P_{in}} = \frac{V^2_{out}/R}{V^2_{in}/R}$$

$$dBm = 10 \log \frac{\frac{V^2}{R}}{10^{-3}} = 10 \log \frac{(.05)^2/50}{10^{-3}} = -13\,dBm$$

for a 50mV signal

REFERENCE PAGE

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Eimbinder, Jerry, Application Considerations for Linear Integrated Circuits, Mactier Publishing Corp., New York, 1970.

Graeme, Jerald, Applications of Operational Amplifiers, Burr-Brown Research Corporation, New York, 1973.

Construction of a Delay Circuit for Data Acquisition Coordination

by Philip Ortiz

Summer Apprenticeship Final Report

Mentor: Captain Ted Kreifels

Illuminator Laboratory
Imaging Branch
Weapons Laboratory
Kirtland Air Force Base

August 17, 1990

Acknowledgements

I would like to thank the following people at the Illuminator Laboratory. Without them, I wouldn't know geography.

Lt. Donna Broome

For helping me every time my mind took a lunch break.

Tsgt. Ray Lagarde

Without him, I'd probably be building my circuit out of staples.

Bob Wilmot

For answering (instead of laughing at) all my stupid questions.

Jeff Baker

When the going gets tough, the tough call Jeff.

Irling (Smitty) Smith

With Smitty: A perfect circuit box.

Without Smitty: A total mess.

Lt. Allison Alexander

For helping me sort out the college clutter crammed into my brain.

And finally, a very special thanks to

Captain Ted Kreifels

When I came, he was my mentor. Now I leave.

He is my friend.

I. Summary

My summer apprenticeship was at the Illuminator Laboratory at Kirtland Air Force Base in Albuquerque, New Mexico. My major project involved building a circuit to delay an input pulse by 1ms and compress the pulse width to 1us. The circuit was used to solve a timing problem between the laboratory's iodine laser and the support equipment used to evaluate its beam characteristics.

II. Introduction

My summer apprenticeship was spent at the Illuminator Laboratory at Kirtland Air Force Base in Albuquerque, New Mexico from June 18, 1990 to August 10, 1990. The Illuminator Laboratory is part of the Advanced Imaging Branch (ARCI) of the Weapons Lab. Its purpose in ARCI is to support advanced imaging field experiments by testing high-energy lasers and evaluating their value as illuminators.

The Illuminator Laboratory is the first critical element in a two year, 18 million dollar series of active imaging experiments at the Starfire Optical Range south of Albuquerque in the Monzano Mountain Range. These experiments require laser light sources with specific qualities and beam characteristics. After nine months of careful consideration, the pulsed photolytic iodine laser was chosen as the most promising coherent illuminator for field experiments. The Illuminator Lab's mission is to (1) integrate the iodine laser into the imaging field experiments, and (2) setup a real-time diagnostic system that fully characterizes the output beam and monitors the laser as it is being operated.

The Illuminator Lab is staffed by the following personnel:

Name	Skill	Position
Capt. Ted Kreifels	Imaging Physicist	Director
Lt. Donna Broome	Science Analyst	Team Chief
TSgt. Ray Lagarde	Electro-Mechanical Tech.	Senior Tech.
Irling Smith	Mechanical Engineer	Engineer
Jeff Baker*	Electrical Engineer	Lead Engr.
Bob Wilmot*	Electro-Optical Tech.	Senior Tech.

* Contracted to KAFB by Rockwell Power Systems

At the Illuminator Lab, I worked in the Laser Diagnostics section of the project(See Figure 1). This section is responsible for gathering and interpreting information on the

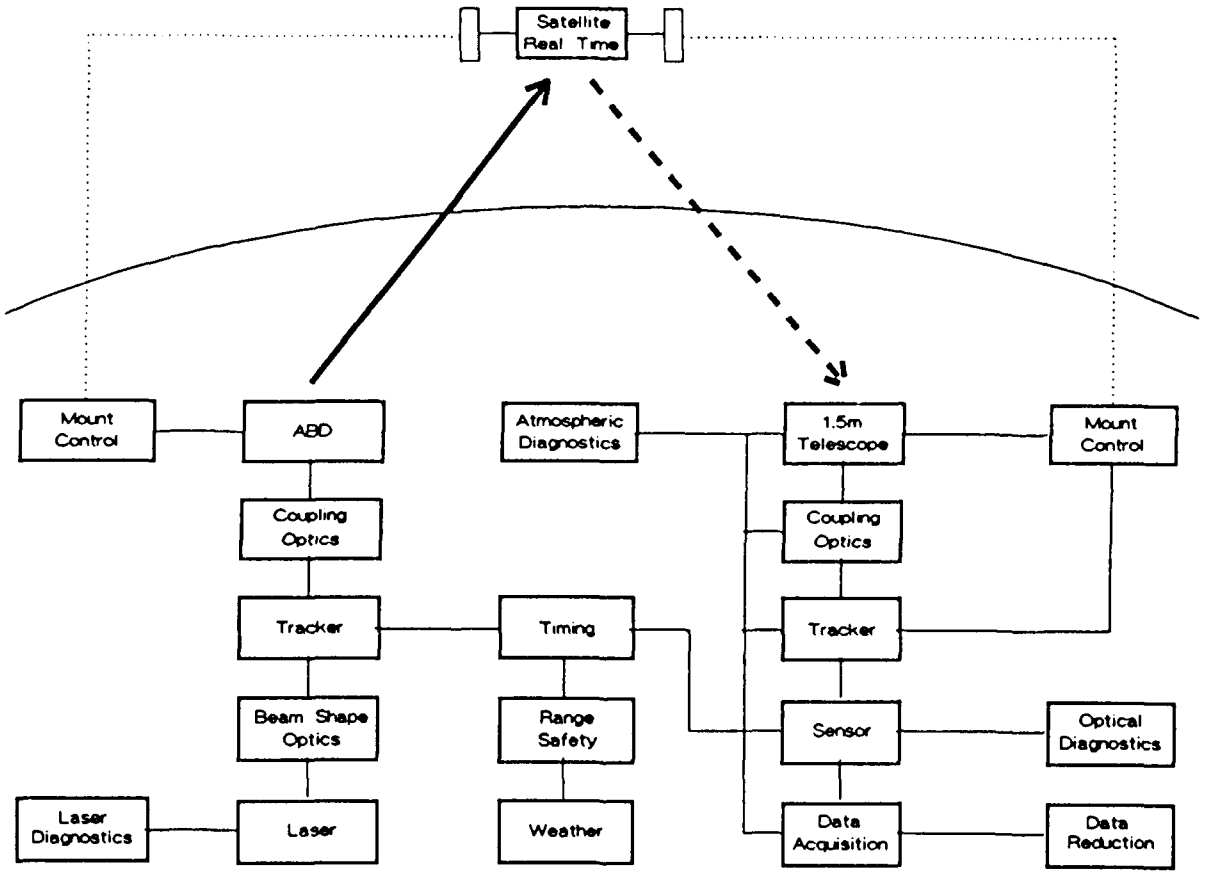


FIG 1 : Mission Breakdown

iodine laser's various characteristics. When I began work, I was initially assigned to learn the C programming language and write a data reduction program for the diagnostics computer. While I was working on the program, a problem arose involving the timing signal for the computer's data acquisition system and the peek and hold (P/H) board. I was then asked to drop my current project and instead concentrate on building a circuit which would modify the timing signal to meet the needs of the computer and the P/H board. My new project consisted of six parts : understanding the circuit design, acquiring the necessary parts and equipment, constructing the circuit, testing, troubleshooting, and mounting the completed circuit in a metal case.

III. Theory

When the iodine laser is fired, it receives a one-half hertz pulse which triggers the firing mechanism (See Figure 2). The beam then travels through a series of diagnostics equipment which measures laser power vs. time, rapid response energy, integrated UV light, polarimeter data, average laser output, and capacitor voltage. These measurements are fed into a data acquisition program via a peek and hold (P/H) board. Note, the P/H board and the computer need to be activated at precisely the right time in order to receive the data from the diagnostics equipment. One way to assure proper timing is to use the original laser triggering pulse to activate the P/H board and the computer. We determined that not only is the triggering pulse incorrectly configured for either of these applications, but it will also arrive at the equipment 1ms too early to be of any use.

My assignment was to build a circuit which would accept the triggering pulse as input, delay it by one millisecond, and produce two outputs. The first output was to be reconfigured by the circuit to a one microsecond pulse width. This output would be used to reset the P/H board and ready it to receive the next batch of data. The second output would be used to activate the computer's data acquisition program. This output was to be a complemented version of the P/H output.

The circuit was comprised of a 74LS123 chip, a 74F04 Hex Invertor chip, two 100k variable resistors, a 0.1uf capacitor, a 100pf capacitor, and connecting wires. Also required for circuit construction were a trial breadboard for initial circuit construction, a solderable breadboard for final construction, a 120V AC to 5V DC power source, a recessed filtered power receptacle, and a standard extension cord.

The circuit (See Figure 3) operates by accepting an input pulse through an invertor and sending it into the 74LS123 duel

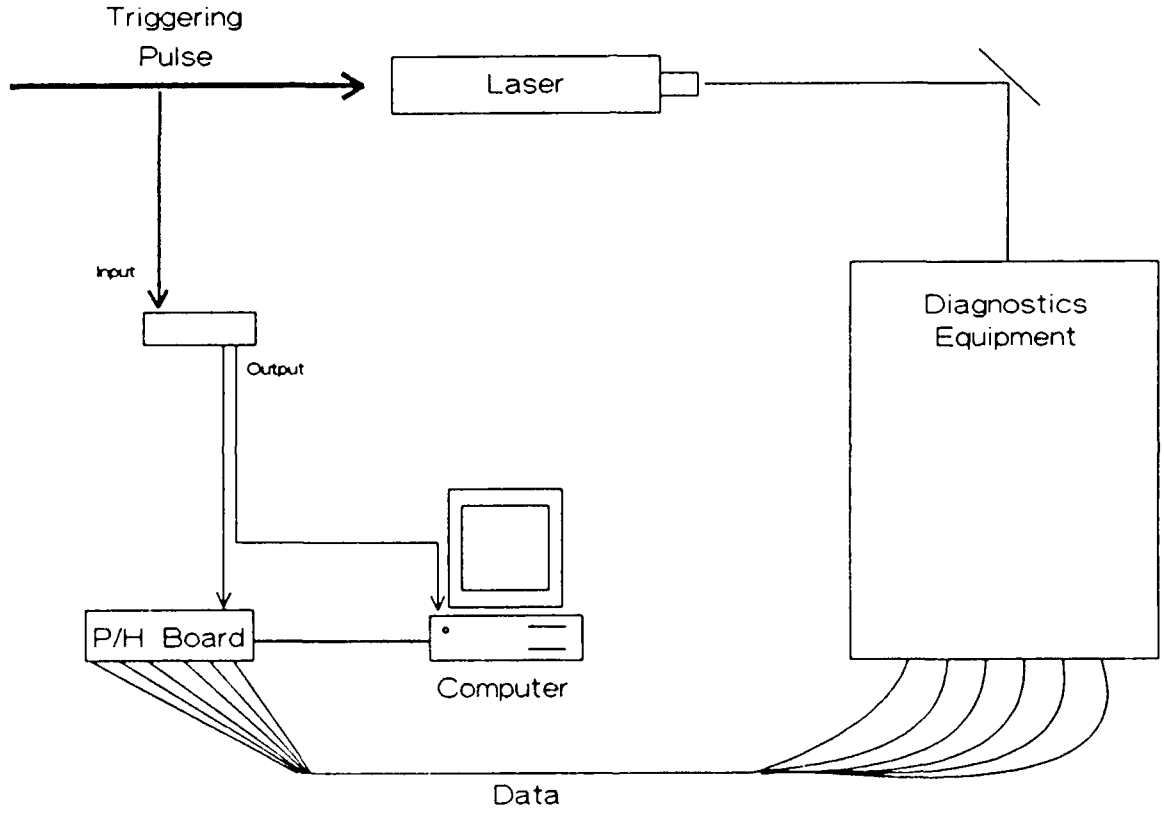


FIG 2: Diagram of laser diagnostic setup with 1ms delay circuit included.

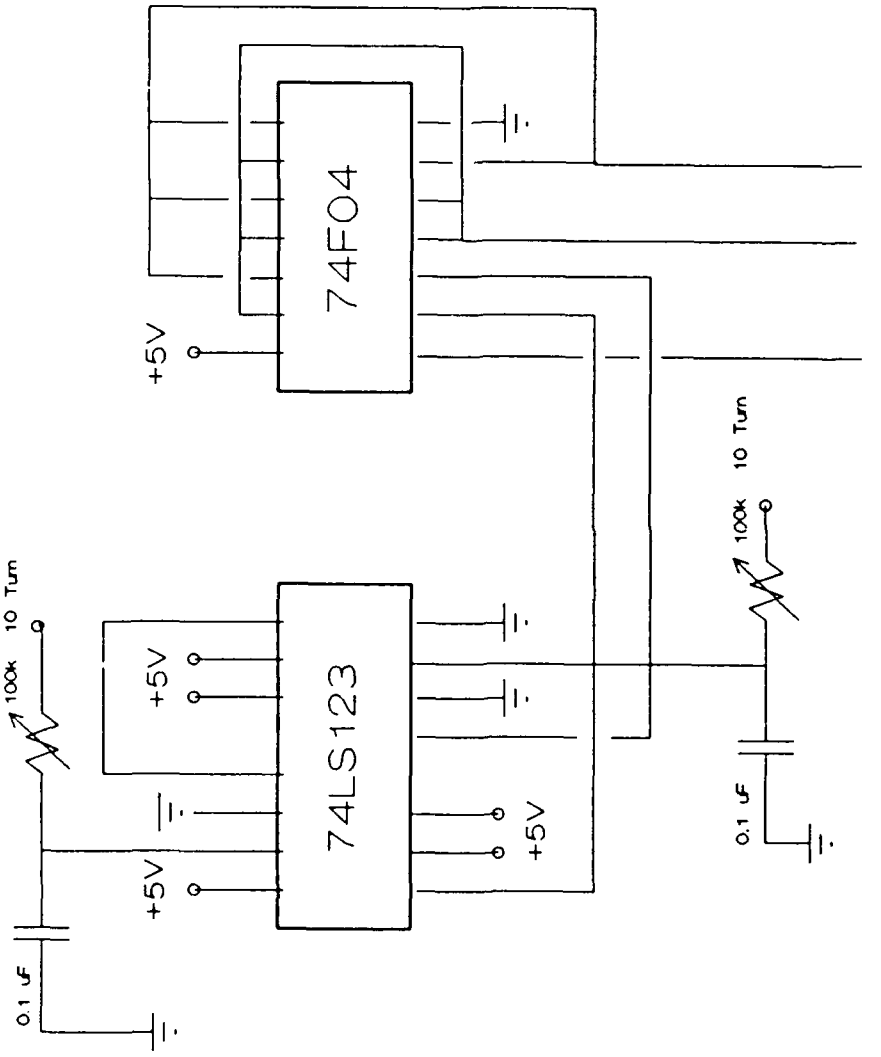


FIG 3: Circuit design

T flip flops. The flip flops then modify the pulse according to the values of the resistors and capacitors hooked to pins 7 and 15. The value of the resistor and capacitor on pin 15 adjust the delay time. In this circuit, the capacitor sets the upper and lower delay limits and the resistor decides the precise delay time. The resistor and capacitor on pin 7 modify the pulse width. The capacitor sets the limits and the resistor defines the final pulse width. The pulse is then redirected to the invertor which complements the output for the computer. Finally, the two modified outputs are sent out to their respective destinations.

After purchasing the necessary parts at the Weapon Laboratory's Consolidated Electronic Project Stock (CEPS) section, I constructed the circuit on the trial breadboard based on the wiring diagram in Figure 3. I powered the circuit by plugging an extension cord into the filtered power receptacle, wiring the receptacle to the 120V AC to 5V DC power source, and then wiring the power source to the voltage and ground strip of the trial breadboard. All wiring was done using solderless crimped terminals.

After the trial circuit was completed, I tested it using a Hewlett Packard Function Generator to generate an input pulse while monitoring the corresponding circuit outputs with a Textronix 454 Oscilloscope. While monitoring the outputs, I adjusted the two variable resistors until I attained the desired delay time and pulse width. After noting the necessary resistor values, I proceeded to transfer my components to the solderable breadboard and begin soldering. When finished, I tested the circuit, corrected a few minor errors, and retested the final product.

After completing the actual circuit, it was time to construct a box that would hold not only the circuit breadboard but the power source and receptacle (See Figure 4). I was provided with a standard metal 8 inch by 12 inch box with screw-in bottom. Mounting the breadboard was relatively easy: I drilled four holes into the box and breadboard and

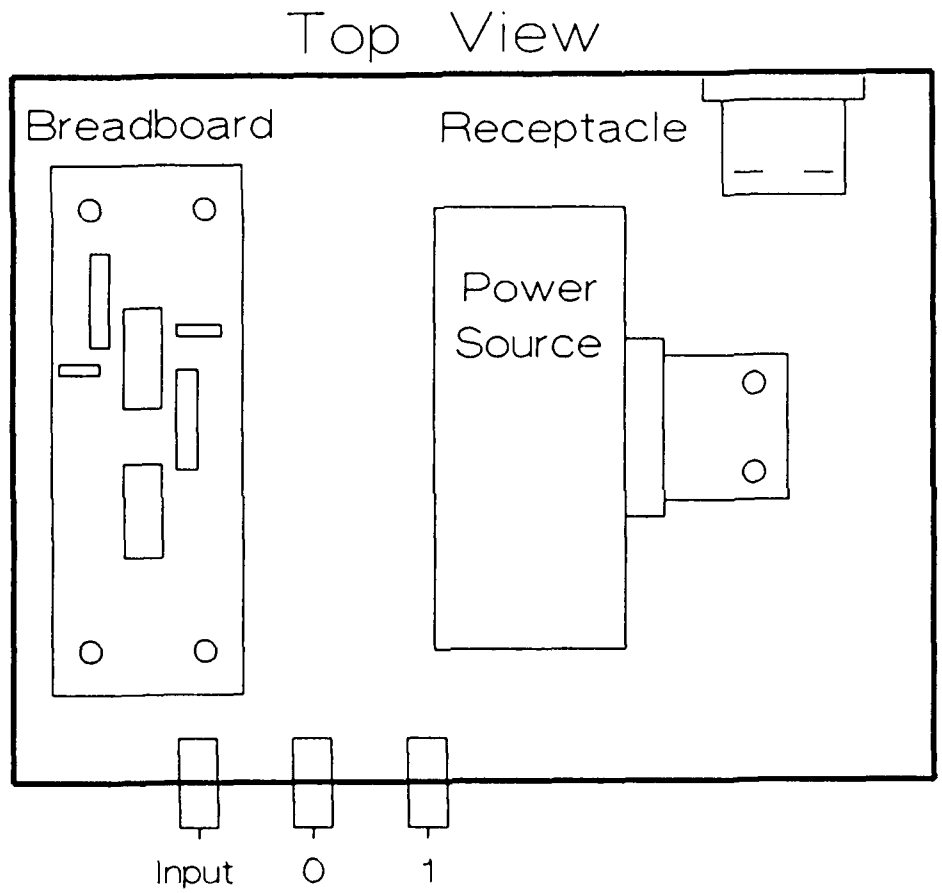
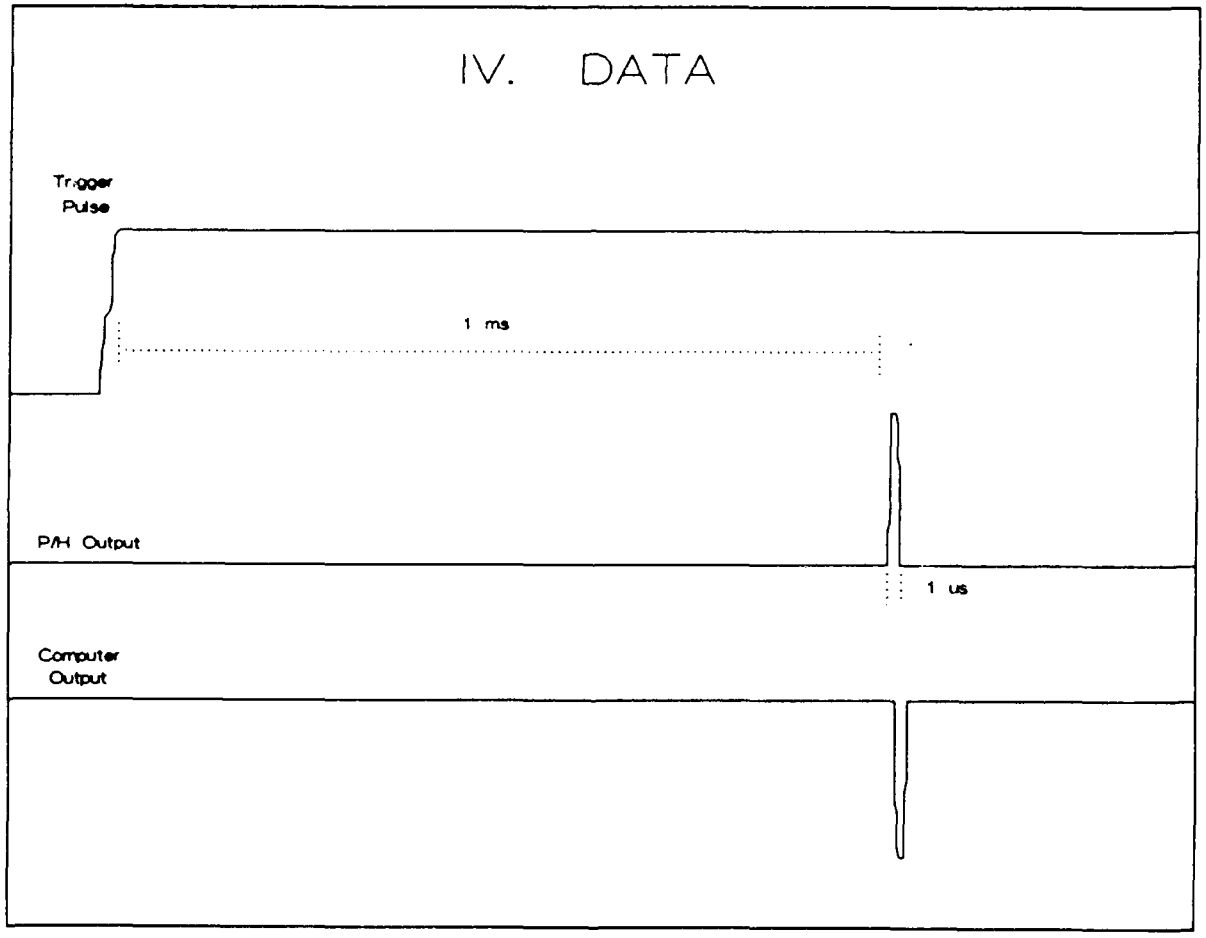


FIG 4: Situation of components in metal box.

mounted the breadboard at the corners using a screw with several nuts in order to keep the breadboard elevated. Next, I mounted the power source. In order to mount the power source, it was first necessary to mount an angle bracket to the box and then secure the power source to the bracket using two mounting holes already present on the power source.

The most challenging task was mounting the power receptacle. Since the receptacle needed to plug into an extension cord, it was necessary to cut a one by three-quarter inch hole in the box to expose the receptacle's plug-in side. I cut the hole by first using a large drill bit to remove most of the metal, then filing down the remaining metal until the surface was smooth. Once the hole was cut, the original receptacle mounting holes were used to screw it into the box.

After completing the circuit box, I tested the final product one last time to assure correct calibration. The circuit was then given to our lead engineer for integration into the laser operating system.



Comparison of input pulse to modified outputs.

V. Conclusion

While working on the delay circuit, I greatly increased my knowledge of digital troubleshooting. In addition, I was able to familiarize myself with a variety of laboratory equipment, including the function generator, the oscilloscope, and other laboratory tools. I also improved my soldering skills dramatically.

After I gave my circuit to our lead engineer, it was retested and integrated into the diagnostics equipment. Now that the timing problem has been solved, the laboratory engineers are working on the final calibration of the iodine laser. Testing should begin within the next year.

My summer apprenticeship at the Weapon's Laboratory at Kirtland AFB was everything I thought it would be and more. I enjoyed my work in the Illuminator Lab immensely and learned a lot more about optics and electronics than I ever could in any other environment. More than anything else, I felt that I had made a contribution to the laboratory. If so, it is one of my proudest accomplishments.

Bibliography

[1] Carlson, Bruce A., Electrical Engineering, Addison- Wesley Publishing Co., 1981

[2] The TTL Data Book, Texas Instruments, Inc., 1976

Contour Plots

Brian Rizzoli

Major Douglas Beason

High Energy Plasma Division

September 31, 1990

Acknowledgments

I would like to thank Captain Thomas Dipp for his help in mathmatical equations and contour plots, Les Bowers, for not only allowing me to share his office space, but also for lessons on UNIX, and finally, I would like to thank my mentor, Major Douglas Beason for all of his help and support.

General Description of Project

Working under Major Beason, I was given the task of writing a program that would create contour plots for regular, gridded data located in various ASCII files. I approached this task through two programs.

The first, xyplot, was an interface to the Fortran Postscript Graphics Library. With mathmatical help from Captain Dipp, I wrote a program to take a set of contour data, create an ASCII sequential file using this data, and execute xyplot on this ASCII file for a resulting postscript plot.

The second program used a much more sophisticated package called NCAR Graphics. Under NCAR Graphics I was able to use an existing subroutine called CONRAN to create contour plots. I wrote a program that would allow a menu driven approach for creating contour plots and give the user control over input and ouput files. With NCAR Graphics, the contour plot could be examined on screen using Xwindows and hard copies could be produced using an Xwindow screen dump or gplot.

The purpose for writing these programs was the VAX computer was being replaced by SUN workstations. All of the previous contour plots had been done on an unconvertable VAX program that would soon be gone. The scientists needed a way of producing contour plots without the VAX computer. The SUN workstation was chosen above a PC for speed, but below the Cray for cost.

Detailed Description of Project

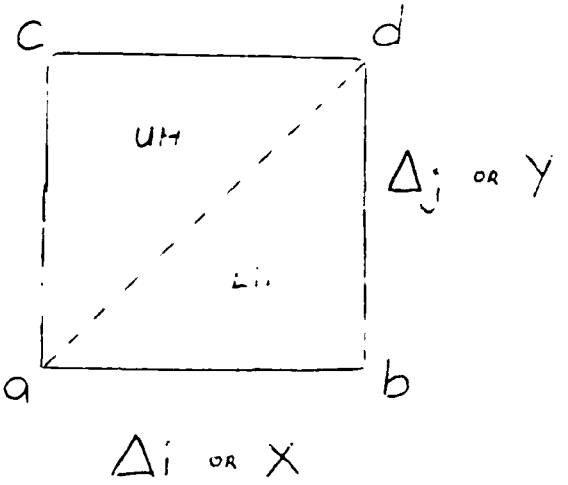
The first program, xycontour.c, was written in the programing language C. I chose C over Fortran because I was more familiar with C and felt comfortable using the language.

Xycontour takes an ASCII data file and creates another ASCII file of a contour plot. This second ASCII file contains information used by xyplot to create a postscript plot. I had to learn xyplot and the Fortran Postscript Graphics Library in order to write xycontour.

I did not possess the mathematical background to create a contour making routine from scratch. Captain Thomas Dipp helped me devise these equations:

$$Z_{LH} = (b-a)di + (d-b)d_j + a$$
$$Z_{UH} = (d-c)di + (c-a)d_j + a$$

$$Z_D = (d-a)di_j + a$$
$$Z_{XLH} = (b-a)di + a$$
$$Z_{YLH} = (d-b)d_j + b$$
$$Z_{XUH} = (d-c)di + c$$
$$Z_{YUH} = (c-a)d_j + a$$



First the gridded data is loaded into computer memory. The program then moves through the rectangular mesh four points, or two triangles, at a time. After finding the minimum and maximum points for the cell, the program checks the users inputed value for the contour interval against the cell's minimum and maximum points. If the inputed contour interval falls between the two points, that contour level is drawn using the five equations.

The lower triangle in the cell is computed first and the upper triagle is computed second. A line is drawn between the equal 'heights' in the cell.

Several problems occur using these equations, however. The program is not suited for data with little change in Z values and will not recognize plateaus, high points, or low points.

While attempting to solve these problems, the NCAR Graphics package was introduced to me. I was instructed to write another program using the built in NCAR Graphics subroutine CONRAN to create contour plots.

The second program, contour.f, was written in Fortran for compatibility when calling the CONRAN Fortran subroutines and for the integration of existing programs.

Contour.f works with both gridded and irregularly spaced data. The data is loaded from a user inputed file and then can transformed inversly, logarithmicly or both. From there the user is given a menu of options in which the contour plot can be controlled. As various options are changed, the program calls the corresponding CONRAN option

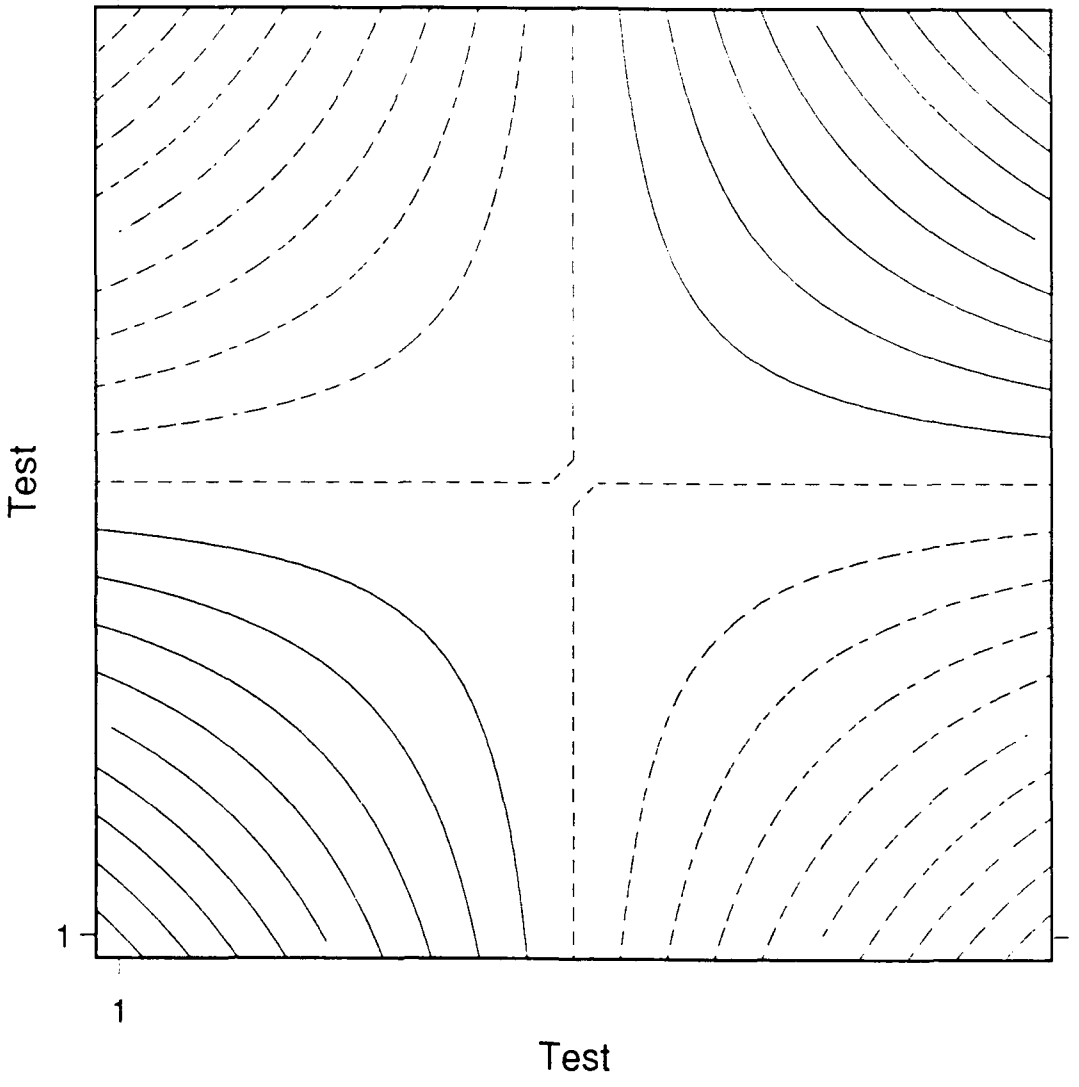
subroutines thus eliminating the lower level programming.

Both xycontour.c and contour.f were written on SUN workstations using the UNIX operating system. Plots were printed on a postscript Laser Writer and a QMS color laser printer.

This summer I have gained an incredible amount of computer experience and science exposure. It was an an intensely exciting summer I know I would like to repeat.

Xycontour.c Examples

Contour Plot



Maximum level : 9936539648.000000

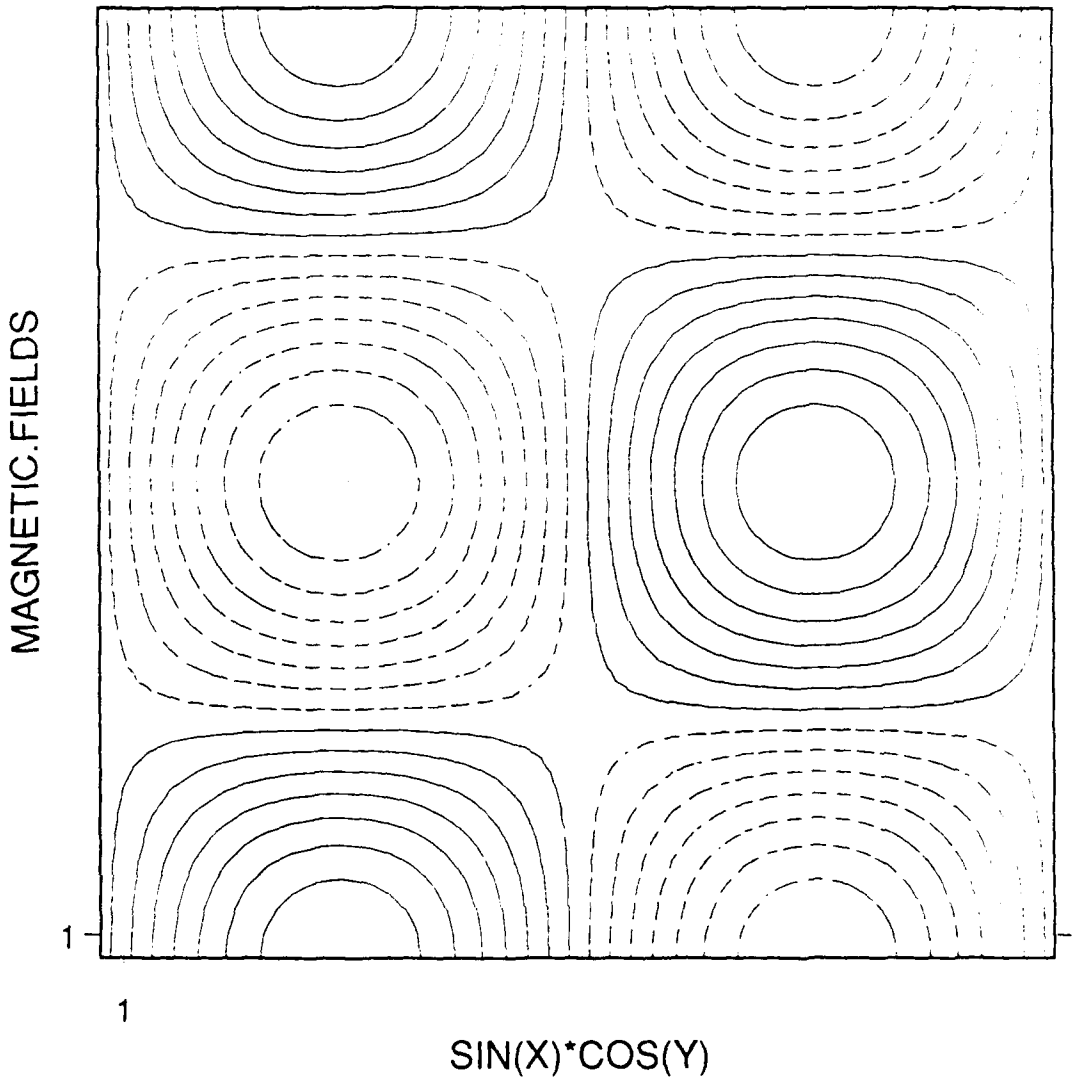
Minimum level : -9936539648.000000

Distance between contour lines : 993653952.000000

Distinction level (Dotted line) : 0.000000

Number of contour lines : 20

Contour Plot



Maximum level : 10.000000

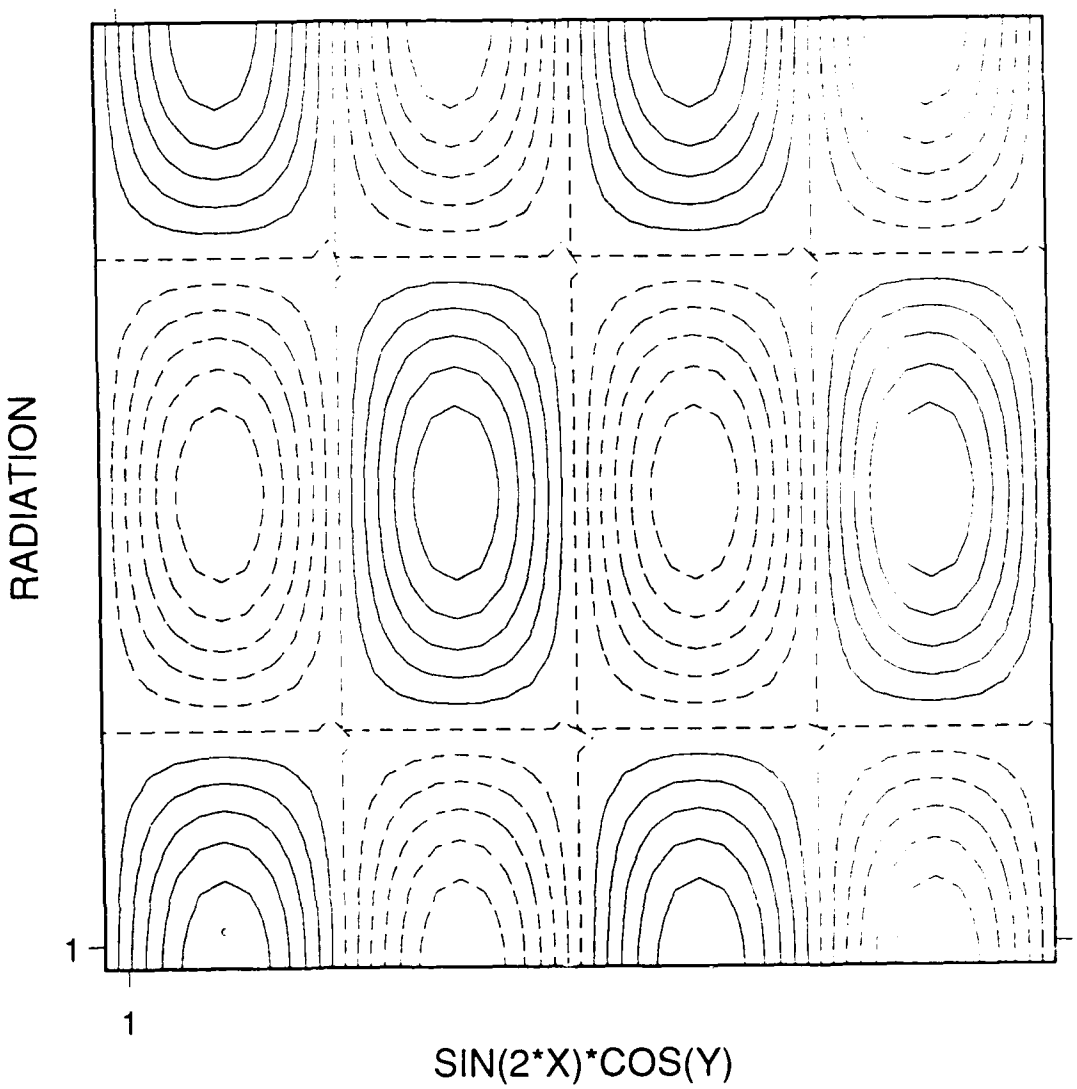
Minimum level : -10.000000

Distance between contour lines : 1.333333

Distinction level (Dotted line) : 0.000000

Number of contour lines : 15

Contour Plot



Maximum level : 10.000000

Minimum level : -10.000000

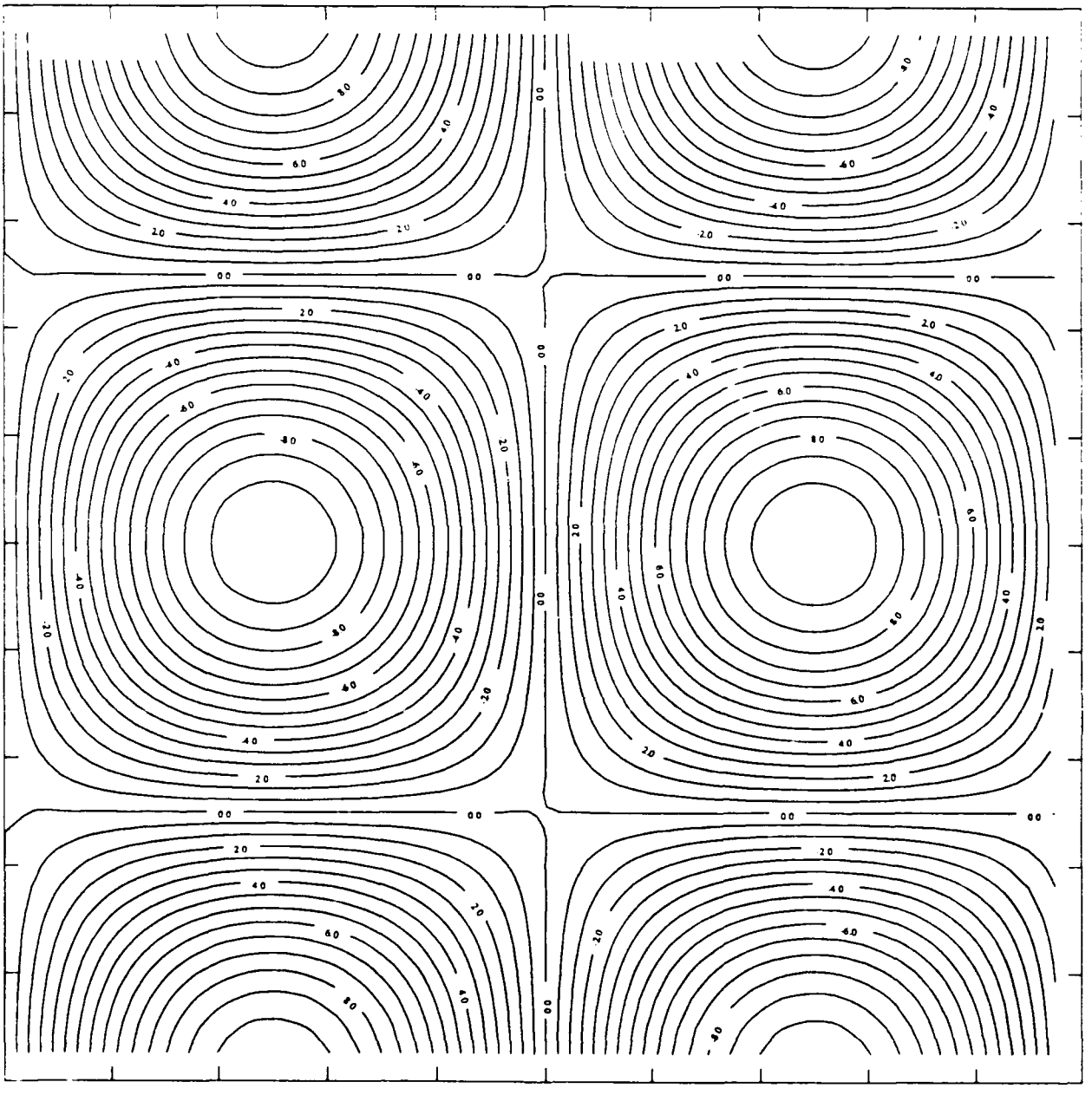
Distance between contour lines : 1.666667

Distinction level (Dotted line) : 0.000000

Number of contour lines : 12

Contour.f Examples

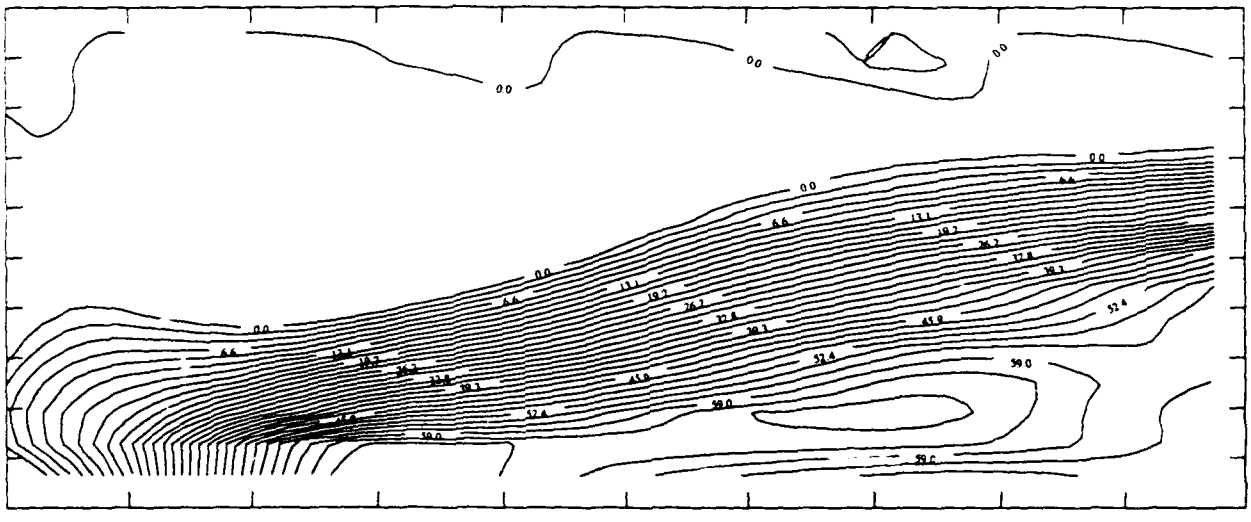
TEST PLOT FOR CONT2



CONTOUR FROM 10.000 TO 9.3339 CONTOUR INTERVAL OF 0.66667

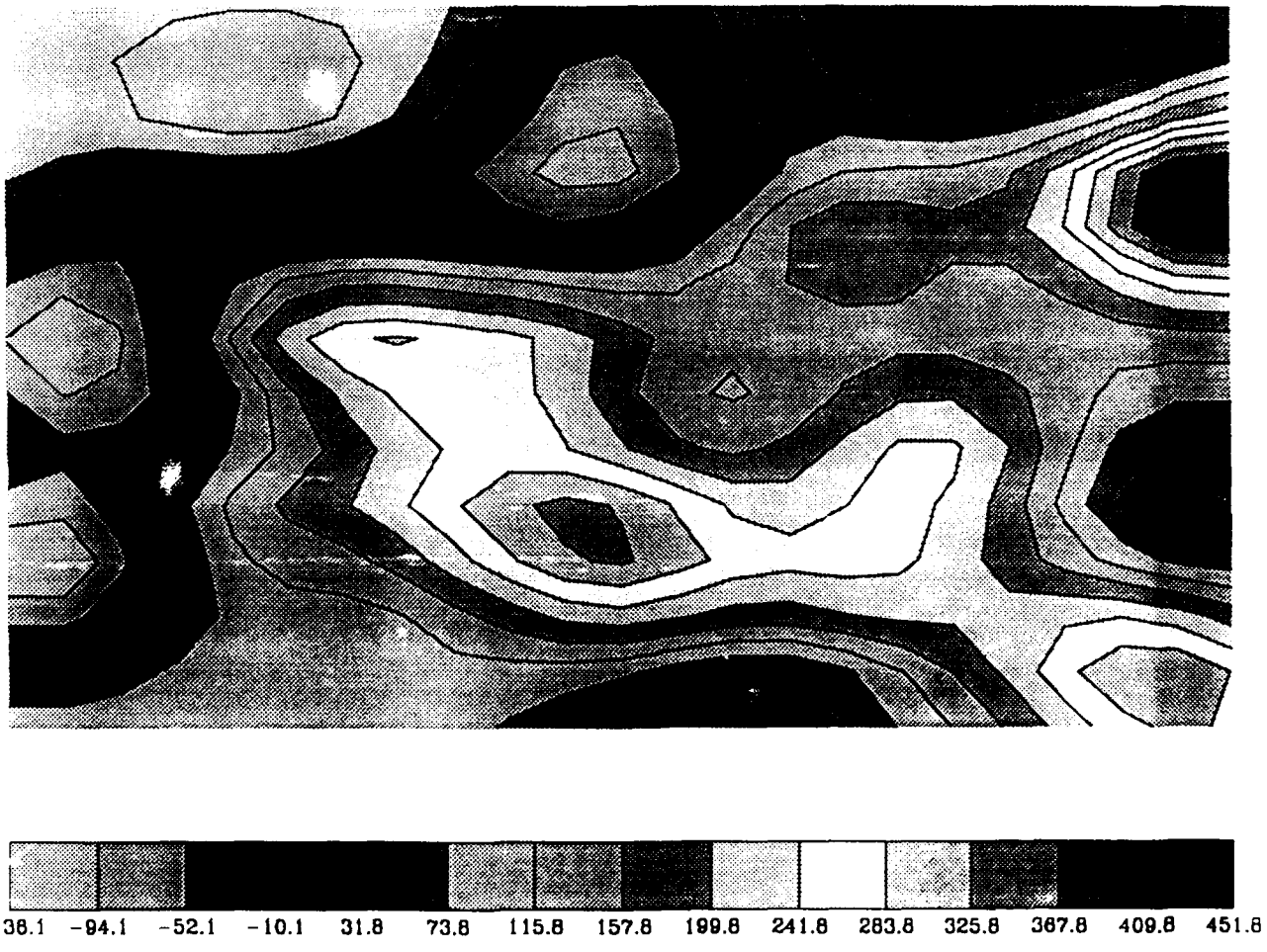
X INTERVAL= 4.0000 Y INTERVAL= 4.0000

TEST PLOT FOR CONT2

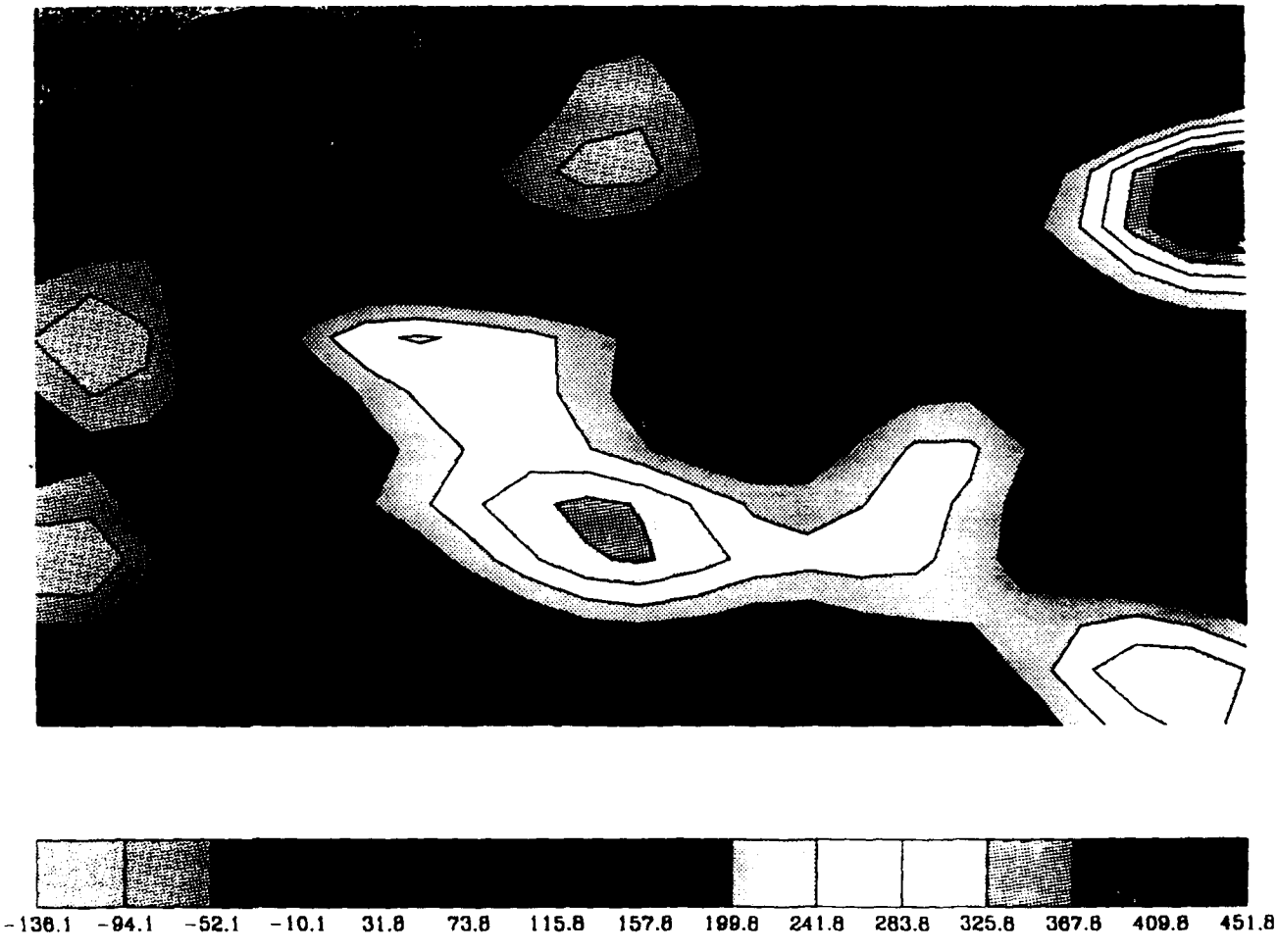


CONTOUR FROM 0 TO 65.317 CONTOUR INTERVAL OF 2.1833
X INTERVAL= 15.000 Y INTERVAL= 6.0750

EXAMPLE 7


-136.1 -94.1 -52.1 -10.1 31.8 73.8 115.8 157.8 199.8 241.8 283.8 325.8 367.8 409.8 451.8

EXAMPLE 7


-136.1
-94.1
-52.1
-10.1
31.8
73.8
115.8
157.8
199.8
241.8
283.8
325.8
367.8
409.8
451.8

Appendices can be obtained from
UNIVERSAL ENERGY SYSTEMS, INC.

Wide Bandwidth Crosslink Register Technical Report

Chris M. Stoltenberg Jr

Capt. James C. Lyke

Air Force Weapons Lab

(Rad-Hard Microelectronics Department)

August 31, 1990

I would like to thank Captain James Lyke for taking me on as an apprentice and for getting me interested in Electrical Engineering. I would also like to thank all of those persons I worked with, Captain Lyke, Samantha, Mr. Sampson, Joe, Ray, Ro, Karen, and Chivon.

Introduction

The Wide Bandwidth Crosslink Register (WBCR) [1] is a device which enables N>2 computers to be hooked together and have uninterrupted access to each other. To facilitate the WBCR, computers had to be purchased. The computers used in this experiment were Commodore Vic-20's. The primary reason these computers were purchased was because they were fairly inexpensive and fairly easy to program. Interfaces had to be designed and built to allow access to the WBCR. Software was also needed to check and see if the WBCR and interface would work correctly.

1 - The Interface for the Vic-20's

An interface was needed to access the WBCR because of the amount of access lines used. As is seen in Figure 1, the WBCR has 22 access lines and the Commodore has only 8 data lines and 3 control lines. The interface manipulates TTL chips. The chips used in the interface were four 74LS377's (Octal D-Type Flip Flops), two 74LS244's (Octal Tri-State Buffers), and one 74LS139 (Dual 1-to-1 Decoder). The chips were wire-wrapped together following the schematic in Figure 2.

2 - Software used to Access the Interface

The software was written in Commodore Vic-20 Basic. Commodore Basic is extremely easy to use for the manipulation of input/output ports. For the case of the interface, the User Port on the Vic-20 was used. The User Port has two 8 line busses that can be used for both input and output. One data bus was selected to be used for all

information to be sent to and read from the WBCR. The other bus was used to send control signals to the 4-to-1 Decoder so that the 4 Octal D-Type Flip Flops could be selected in a certain order so as to read and write to all 10 input and output lines and the 2 control lines on the WBCR. The commands used in Commodore Basic to access the Data Direction Registers (DDRs) and to read or write information out were the PEEK and POKE statements. POKE was used to set the DDRs to either input or output. The 8 data lines have both a DDR and a Register to read or write information. The four memory locations for these statements were 37136, 37137, 37138, and 37139. To set both busses, the data and control busses, to output, the statement 'POKE 37138,255: POKE 37139,255', was needed in a program. To set both statements to input, 255 was replaced with a zero.

To read information from the WBCR, the PEEK statement had to be used. PEEK looks into a memory location and assigns a variable the number in that memory location. For example, X=PEEK(37136), would place the number in memory locataion 37136 into the variable X. As it happens, the previous statement is what was used to read data from the 8 data lines in the User Port. To get the value from the data lines, the interface had to be set to read from the right input chip, the User Port's 8 data lines had to be set for input, and the WBCR had to select which computer the information would come from. The statement used to get all of this done was, assuming that the computer to read from was already selected, 'POKE 37138,0:POKE 37139,255: POKE 37137,16: VAL=PEEK(37136) .' This statement, of course, is a brief synopsis of what was needed. For further, detailed

statements, see the Listings included.

For the testing of the interface through programs, the TTL chips for output and the TTL chips for input were set up, through the decoder, so that when a zero was sent to the decoder, output chip#1 was selected; when an eight was sent, output chip#2 was selected; when a sixteen was sent, input chip#1 was selected; and when a twenty-four was sent, input chip#2 was selected.

To test the interface, 8 LEDs were attached to the output chips, and 8 switches were attached to the input chips. A simple test program was developed to send out numbers from 0 to 255. The LEDs lighted in a binary count to the outcoming of the numbers. A second program was created to read numbers, in binary, off of the switches. Both programs worked flawlessly. Samples of these programs, however, were lost by accident.

3 - The Wide Bandwidth Crosslink Register

The WBCR is an extremely efficient method for the interconnection of N different digital interconnection units (DIUs). DIUs are equipment such as microprocessors and analog-to-digital converters. The WBCR runs in a parallel atmosphere. To date there are very few programs that will efficiently run in parallel. The WBCR opens up many possibilities to use for future parallel processing. The WBCR can also be used to hook up different types of computers in parallel. For example an Amiga, an IBM, and an Apple can all be hooked together and have no problems with communication.

4 - Software Used to Facilitate the WBCR

The software used to run the WBCR is very much like that for the interface. The WBCR had 10 input lines, 10 output lines, and 2 control lines. The control lines were used to select which computer hooked into the WBCR to read from.

To use the select lines, the interface had to be set to enable the use of output chip#2 and the 2 control lines. The Basic line statement to do this was 'POKE37138,255: POKE37139,255:POKE37137,8:POKE37136,integer'. 'Integer' was a number, 0,4,8,12, used to select computer 1,2,3,4, respectively.

5 - Example Program [2]

The example program used to test and see if the WBCR would work in parallel was a simple simulation. 4 walls of charges were set up and each particle in the walls was given a courtesian coordinate. Each computer, there were 4, had control of one of the four quadrants. There was also a charge in the middle equal to and opposite of all the charged particles in the walls. The basic idea behind this simulation was that a particle placed inside the walls would eventually obtain a fixed orbit. However, this was not the case because the Commodores worked the math in integer form, thus losing many significant digits. This program never was tested on the WBCR because time ran out for th experiment. The program did work on an IBM, so it would be reasonably safe to assume that it would work on the Commodores hooked up in parallel through the WBCR. Each computer had its own program and own quadrant. Computer 1 had quadrant 1. Computer 2 had quadrant 2. Computer 3 had quadrant 3. Computer 4 had quadrant 4. These programs are listed as

listings 1,2,3 and 4.

6 - Problems Occurring with the Experiment

Only one major problem, occurred during the experiment. This problem was that the WBCR was not fabricated correctly and had to be refabricated. Time was limited for this experiment, and having this problem occur, ran time down almost all of the way. There was not time enough to thoroughly test the WBCR.

Figure #2

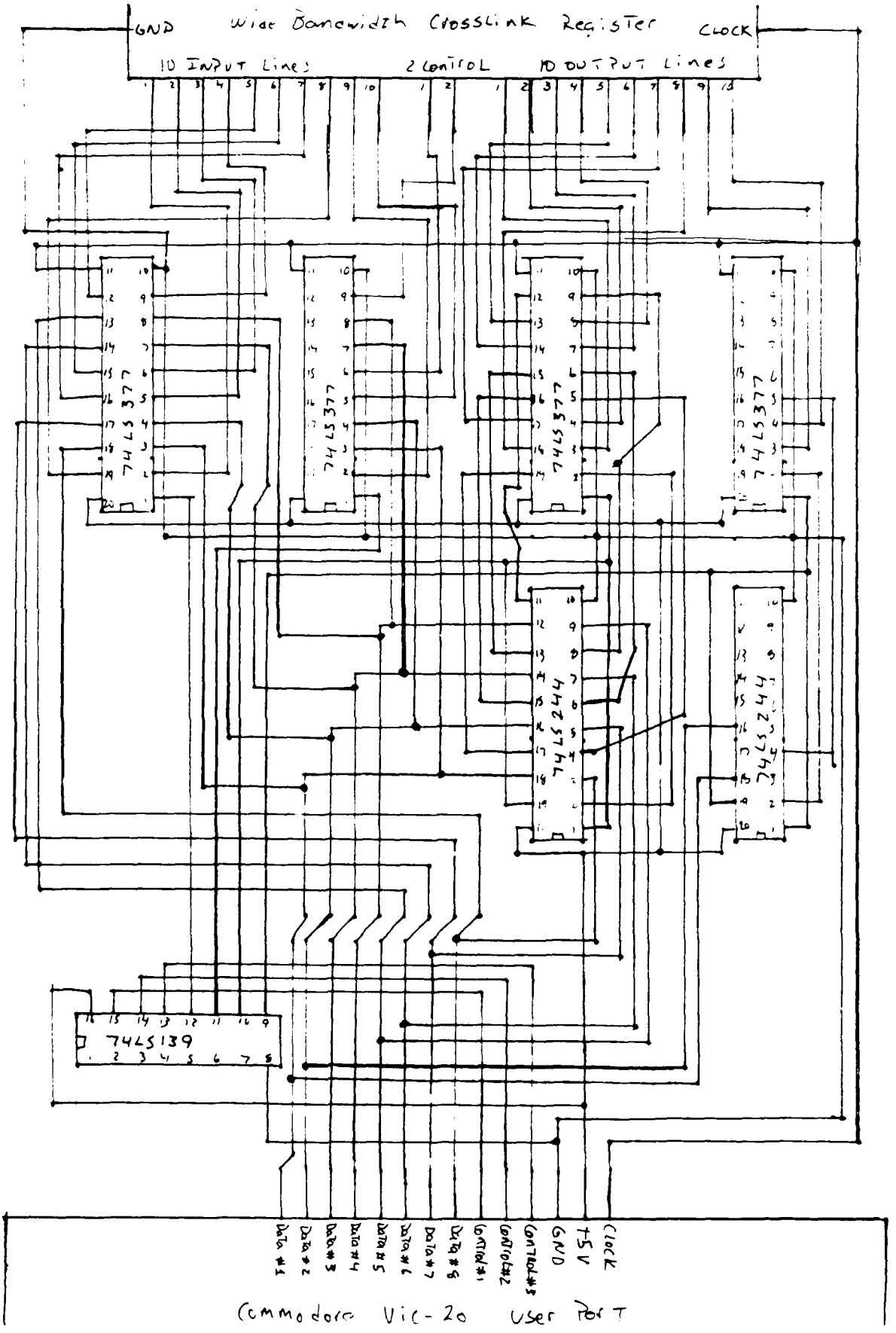
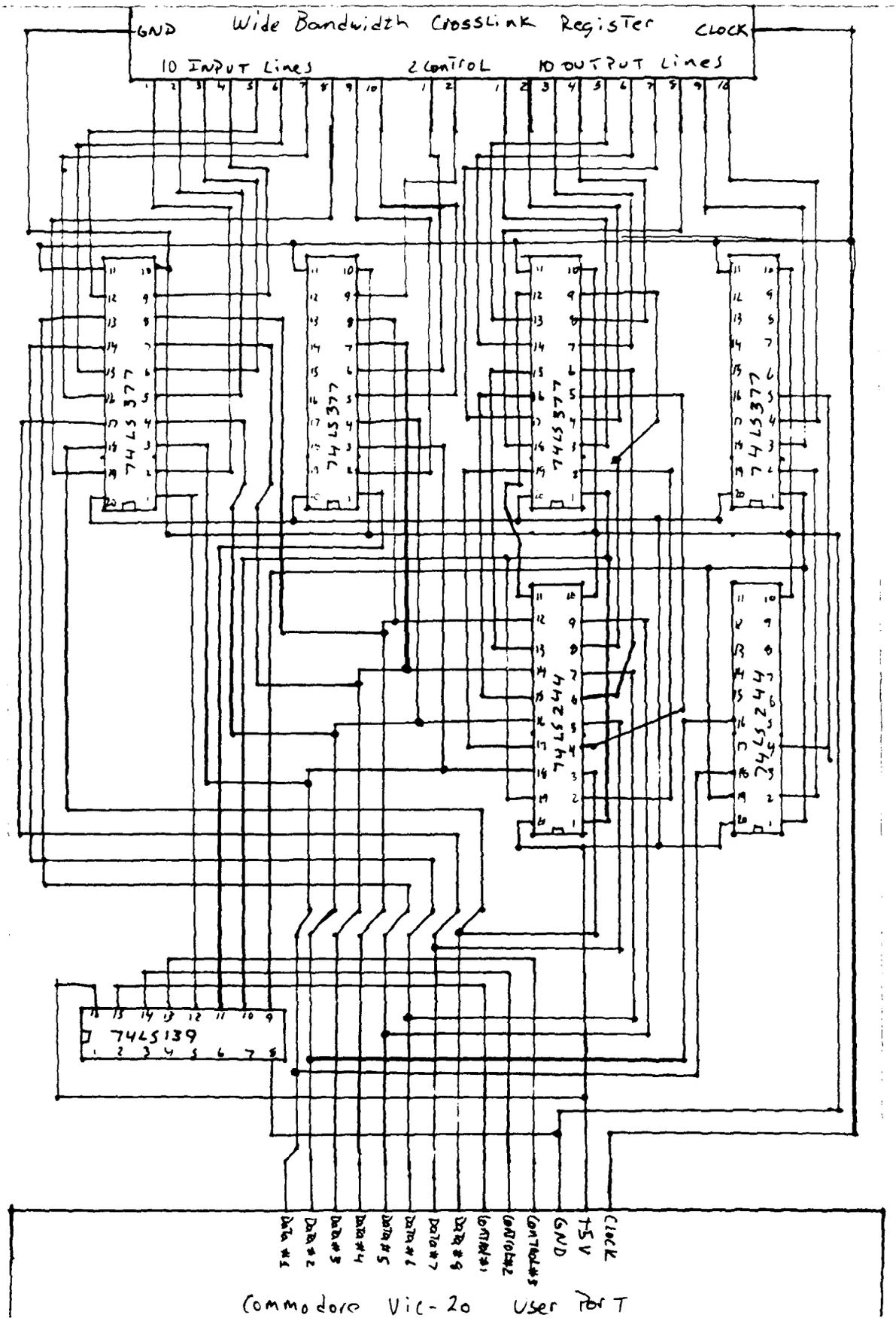

GND
Wide Bandwidth Crosslink Register
CLOCK
10 INPUT LINES
2 CONTROL
10 OUTPUT LINES
74LS377
74LS377
74LS377
74LS377
74LS244
74LS244
74LS139
Data #1
Data #2
Data #3
Data #4
Data #5
Data #1
Data #7
Data #8
Control #1
Control #2
Control #3
GND
+5V
CLOCK
Commodore Vic-20 User Port

Figure #2



Commodore Vic-20 User Port

```
0 REM *****MAIN PROGRAM FOR VIC#1*****
1 PRINT"□":REM *CLEARS SCREEN*
9 REM ****INITIAL SETUP LOOP****
10 DIM X(50):DIM Y(50):N=0:SCALE=.005
14 REM ***ASSIGN X AND Y VALUES TO X AND Y ARRAYS***
15 Y=22
20 FOR X=0TO21:N=N+1:X(N)=X:Y(N)=Y:NEXTX
25 X=21
30 FOR Y=22TO1STEP-1:N=N+1:X(N)=X:Y(N)=Y:NEXTY
34 REM ***INPUT ALL NEEDED INITIAL VALUES***
35 INPUT"INIT X,Y";X0,Y0
40 INPUT"INIT VEL (MAG,ANGLE)";VMAG,VTHETA
45 INPUT"GRAVITY";SCALE
49 REM ***BREAK UP VELOCITY VECTOR INTO X VELOCITY AND Y VELOCITY***
50 SX=VMAG*COS(VTHETA/180*π)
55 SY=VMAG*SIN(VTHETA/180*π)
99 REM ****DRAW PARTICLES ON SCREEN LOOP****
100 PRINT"□"
101 FOR I=1TON:X=X(I):Y=Y(I):SHP=81:COLR=2:GOSUB1000:NEXT
125 PRINT"SY=";Y0
149 REM ****DRAW TEST CHARGE ON SCREEN****
150 IFX0>=0ANDY0>=1THEN160
155 GOTO199
160 X=X0:Y=Y0:SHAPE=87:COLR=5:GOSUB1000
199 REM ****OUTPUT LOOP****
200 DAT=X0:GOSUB2000
205 DAT=Y0:GOSUB2000
249 REM ****MAIN CALCULATION LOOP (EQUATIONS OF MOTION)****
250 FORB=1TON
255 X1=X0-X(B):Y1=Y0-Y(B):X2=X(B)-X0:Y2=Y(B)-Y0
260 ALPHA=-ATN(Y1/(X1+(X1=0)))*(X1<>0)-π*((X1<0)+.5*SGN(Y1)*(X1=0))
265 SX=SX+COS(ALPHA)*SCALE/ABS(X2+(X2=0))
270 SY=SY+SIN(ALPHA)*SCALE/ABS(Y2+(Y2=0))
275 NEXTB
299 REM ****INPUT LOOP****
300 FORVIC=4TO12STEP4:GOSUB3000:NEXT
349 REM ****SECONDARY CALCULATION LOOP****
350 X0=X0+SX:Y0=Y0+SY:PRINT"SY=";Y0
355 GOTO149
1000 POKE4118+X+(22*(22-Y)),SHP:POKE37910+X+(22*(22-Y)),COLR:RETURN
1001 REM *IN ABOVE STATEMENT CHANGE POKE4118 TO POKE 7702 WHEN MEM ADDED IS NOT
> 8K*
1002 REM *IN ABOVE STATEMENT CHANGE POKE37910 TO POKE38422 WHEN MEM ADDED IS NOT
 > 8K*
2000 REM ****THE SUBROUTINE FOR WRITING VALUES TO THE OTHER COMPUTERS****
2005 POKE37138,255:REM *SETS THE DDR TO OUTPUT FOR 8 DATA LINES*
2010 POKE37139,255:REM *SETS THE DDR TO OUTPUT FOR 3 CONTROL LINES*
2015 POKE37137,4:REM *DISABLES ALL I/O CHIPS ON INTERFACE*
2020 POKE37136,3:REM *PLACES A VALUE OF 3 INTO 8 DATA LINES*
2025 POKE37137,8:REM *SELECTS OUTCHIP2 AND LETS VALUE IN 8 DATA LINES THROUGH*
2030 POKE37137,4:REM *SEE LINE 2015*
2035 POKE37136,DAT:REM *PLACES VALUE OF DAT INTO 8 DATA LINES*
2040 POKE37137,0:REM *SELECTS OUTCHIP1 AND LETS VALUE IN 8 DATA LINES THROUGH*
2045 POKE37137,4:REM *SEE LINE 2015*
2049 REM ***LOOP TO MAKE SURE OTHER COMPUTERS HAVE RECIEVED THE DATA SENT***
2050 FOR SEL=0TO12STEP4
2051 RE=0
2055 POKE37136,SEL:REM *PLACES VALUE OF SEL INTO 8 DATA LINES*
2060 POKE37137,8:REM *SEE LINE 2025*
2065 POKE37137,4:REM *SEE LINE 2015*
2070 POKE37138,0:REM *SETS DDR TO INPUT FOR 8 DATA LINES*
```

```
2075 POKE37137,24:REM *SELECTS INCHIP2*
2080 NUM=PEEK(37136):REM *READS DATA IN 8 DATA LINES TO NUM*
2085 IF NUM=1 THEN RE=RE+1
2090 NEXTSEL
2095 IF RE<3 THEN 2050:REM *INSURES THAT ALL 3 COMPUTERS HAVE RESPONDED*
3100 RETURN
3000 REM ****SUBROUTINE FOR READING VALUES CALCULATED BY OTHER COMPUTERS****
3005 POKE37138,255:REM *SETS THE DDR TO OUTPUT FOR 8 DATA LINES*
3010 POKE37139,255:REM *SETS THE DDR TO OUTPUT FOR 3 CONTROL LINES*
3015 POKE37137,4:REM *DISABLES ALL I/O CHIPS ON INTERFACE*
3020 POKE37136,VIC:REM *PLACES VALUE OF VIC INTO 8 DATA LINES*
3025 POKE37137,8:REM *SELECTS OUTCHIP2 AND LETS VALUE IN 8 DATA LINES THROUGH*
3030 POKE37137,4:REM *SEE LINE 3015*
3035 POKE37138,0:REM *SETS THE DDR TO INPUT FOR 8 DATA LINES*
3040 POKE37137,24:REM *SELECTS INCHIP2*
3045 NUM=PEEK(37136):REM *READS VALUE IN 8 DATA LINES AND PUTS IN NUM*
3050 IF NUM=3THEN3060
3055 GOTO3000
3060 POKE37137,4:REM *SEE LINE 3015*
3065 POKE37137,16:REM *SELECTS INCHIP1*
3070 DAT=PEEK(37136):REM *READS VALUE IN 8 DATA LINES AND PUTS IN DAT*
3075 SX=SX+DAT
3080 POKE37137,4:REM *SEE LINE 3015*
3085 POKE37138,255:REM *SEE LINE 3005*
3090 POKE37136,1:REM *PLACES VALUE OF 1 INTO 8 DATA LINES*
3095 POKE37137,8:REM *SEE LINE 3025*
3100 POKE37138,255:REM *SEE LINE 3005*
3105 POKE37139,255:REM *SEE LINE 3010*
3110 POKE37137,4:REM *SEE LINE 3015*
3115 POKE37136,VIC:REM *SEE LINE 3020*
3120 POKE37137,8:REM *SEE LINE 3025*
3125 POKE37137,4:REM *SEE LINE 3015*
3130 POKE37138,0:REM *SEE LINE 3035*
3135 POKE37137,24:REM *SEE LINE 3040*
3140 NUM=PEEK(37136):REM *SEE LINE 3045*
3145 IFNUM=3THEN3155
3150 GOTO3100
3155 POKE37137,4:REM *SEE LINE 3015*
3160 POKE37137,16:REM *SEE LINE 3065*
3165 DAT=PEEK(37136):REM *SEE LINE 3070*
3170 SY=SY+DAT
3175 POKE37137,4:REM *SEE LINE 3015*
3180 RETURN

READY.
```

```
0 REM *****MAIN PROGRAM FOR VIC#2*****
1 PRINT"J":REM *CLEARS SCREEN*
2 REM ****INITIAL SETUP LOOP****
10 DIM X(50):DIM Y(50):N=0:SCALE=.005
14 REM ***ASSIGN X AND Y VALUES TO X AND Y ARRAYS***
15 X=-21
20 FORY=1TO22:N=N+1:X(N)=X:Y(N)=Y:NEXTY
25 Y=22
30 FORX=-21TO-1:N=N+1:X(N)=X:Y(N)=Y:NEXTX
95 REM ****DRAW PARTICLES ON SCREEN LOOP****
100 FOR I=1TON:X=X(I):Y=Y(I):SHP=81:COLR=2:GOSUB1000:NEXT
149 REM ****INPUT LOOP****
150 VIC=0:GOSUB3000
155 XO=DAT
160 VIC=0 GOSUB3000
165 YO=DAT
170 PRINT"SX=";XO
199 REM ****DRAW TEST CHARGE ON SCREEN****
200 IFXO<=-1ANDYO>=1THEN210
205 GOTO249
210 X=XO:Y=YO:SHAPE=87:COLR=5:GOSUB1000
249 REM ****MAIN CALCULATION LOOP (EQUATIONS OF MOTION)****
250 SX=0:SY=0
255 FORB=1TON
260 X1=XO-X(B):Y1=YO-Y(B):X2=X(B)-XO:Y2=Y(B)-YO
265 ALPHA=-ATN(Y1/(X1+(X1=0)))*(X1<>0)-π*((X1<0)+.5*SGN(Y1)*(X1=0))
270 SX=SX+COS(ALPHA)*SCALE/ABS(X2+(X2=0))
275 SY=SY+SIN(ALPHA)*SCALE/ABS(Y2+(Y2=0))
280 NEXTB
299 REM ****OUTPUT LOOP****
300 DAT=SX:GOSUB2000
305 DAT=SY:GOSUB2000
349 REM ****RETURN TO INPUT LOOP TO AWAIT NEXT INCOMING VALUES****
350 GOTO 150
1000 POKE4118+(22+X)+(22*(22-Y)),SHP:POKE37910+(22+X)+(22*(22-Y)),COLR:RETURN
1001 REM *IN ABOVE STATEMENT CHANGE POKE4118 TO POKE7702 WHEN MEM ADDED IS INPU
T8K*
1002 REM *IN ABOVE STATEMENT CHANGE POKE37910 TO POKE38422 WHEN MEM ADDED IS < 8
K*
2000 REM ****THE SUBROUTINE FOR SENDING VALUES BACK TO COMPUTER#1****
2005 POKE37138,255:REM *SETS THE DDR TO OUTPUT FOR 8 DATA LINES*
2010 POKE37139,255:REM *SETS THE DDR TO OUTPUT FOR 3 CODNTROL LINES*
2015 POKE37137,4:REM *DISABLES ALL I/O CHIPS ON INTERFACE*
2020 POKE37136,3:REM *PLACES A VALUE OF 3 INTO 8 DATA LINES*
2025 POKE37137,8:REM *SELECTS OUTCHIP2 AND LETS DATA IN 8 LINES THROUGH*
2030 POKE37137,4:REM *SEE LINE 2015*
2035 POKE37136,DAT:REM *PLACES VALUE OF DAT INTO 8 DATA LINES*
2040 POKE37137,0:REM *SELECTS OUTCHIP1 AND LETS DATA IN 8 LINES THROUGH*
2045 POKE37137,4:REM *SEE LINE 2015*
2049 REM ***LOOP TO ENSURE VIC#1 HAS RECIEVED DATA***
2050 SEL=0
2055 POKE37136,SEL:REM *PLACES VALUE OF SEL INTO 8 DATA LINES*
2060 POKE37137,8:REM *SEE LINE 2025*
2065 POKE37137,4:REM *SEE LINE 2015*
2070 POKE37138,0:REM *SETS DDR TO INPUT FOR 8 DATA LINES*
2075 POKE37137,24:REM *SELECTS INCHIP2*
2080 NUM=PEEK(37136):REM *READS VALUE IN 8 DATA LINES AND PLACES IN NUM*
2085 IF NUM=1 THEN 2095
2090 NUM=0:GOTO2080
2095 RETURN
3000 REM ****SUBROUTINE FOR READING VALUES FROM VIC#1****
```

```
3005 POKE37138,255:REM *SETS DDR TO OUTPUT FOR 8 DATA LINES*
3010 POKE37139,255:REM *SETS DDR TO OUTPUT FOR 3 CONTROL LINES*
3015 POKE37137,4:REM *DISABLES ALL I/O CHIPS ON THE INTERFACE*
3020 POKE37136,VIC:REM *PLACES VALUE OF VIC IN THE 8 DATA LINES*
3025 POKE37137,8:REM *SELECTS OUTCHIP2 AND LETS THE DATA IN 8 LINES THROUGH*
3030 POKE37137,4:REM *SEE LINE 3015*
3035 POKE37138,0:REM *SETS DDR TO INPUT FOR 8 DATA LINES*
3040 POKE37137,24:REM *SELECTS INCHIP2*
3045 NUM=PEEK(37136):REM *READS DATA IN 8 DATA LINES INTO NUM*
3050 IF NUM=0THEN3060
3055 NUM=0:GOTO3045
3060 POKE37137,4:REM *SEE LINE 3015*
3065 POKE37137,16:REM *SELECTS INCHIP1*
3070 DAT=PEEK(37136):REM *READS VALUE IN 8 DATA LINES AND PLACES IN DAT*
3075 POKE37137,4:REM *SEE LINE 3015*
3080 POKE37138,255:REM *SEE LINE 3005*
3085 POKE37136,1:REM *PLACES VALUE OF 1 IN 8 DATA LINES*
3090 POKE37137,8:REM *SEE LINE 3025*
3095 POKE37137,4:REM *SEE LINE 3015*
3100 RETURN

READY.
```

```
0 REM *****MAIN PROGRAM FOR VIC#3*****
1 PRINT"□":REM *CLEARS SCREEN*
4 REM ****INITIAL SETUP LOOP****
10 DIM X(500):DIM Y(500):N=0:SCALE=.005
14 REM ***ASSIGN X AND Y VALUES TO X AND Y ARRAYS***
15 Y=-22
20 FORX=-21TO-1:N=N+1:X(N)=X:Y(N)=Y:NEXTX
25 X=-21
30 FORY=-22TO0:N=N+1:X(N)=X:Y(N)=Y:NEXTY
99 REM ****DRAW PREVIOUS CLEE ON SCREEN LOOP****
100 FOR I=1TON:X=X(I):Y=Y(I):SHP=81:COLR=2:GOSUB1000:NEXT
149 REM ****INPUT LOOP****
150 VIC=0:GOSUB3000
155 X0=DAT
160 VIC=0:GOSUB3000
165 Y0=DAT
199 REM ****DRAW TEST CHARGE ON SCREEN****
200 IFX0<>-1ANDY0<>0THEN210
205 GOTO249
210 X=X0:Y=Y0:SHAPE=37:COLR=5:GOSUB1000
249 REM ****MAIN CALCULATION LOOP (EQUATIONS OF MOTION)****
250 SX=0:SY=0
255 FORB=1TON
260 X1=X0-X(B):Y1=Y0-Y(B):X2=X(B)-X0:Y2=Y(B)-Y0
265 ALPHA=-ATN(Y1/(X1+(X1=0)))*(X1<>0)-π*((X1<0)+.5*SGN(Y1)*(X1=0))
270 SX=SX+COS(ALPHA)*SCALE/ABS(X2+(X2=0))
275 SY=SY+SIN(ALPHA)*SCALE/ABS(Y2+(Y2=0))
280 NEXTB
299 REM ****OUTPUT LOOP****
300 DAT=SX:GOSUB2000
305 DAT=SY:GOSUB2000
349 REM ****RETURN TO INPUT LOOP TO AWAIT NEXT INCOMING VALUES****
350 GOTO 150
1000 POKE4580+(22+X)-(22*(22+Y)),SHP:POKE38372+(22+X)-(22*(22+Y)),COLR:RETURN
1001 REM *CHANGE POKE4580 TO POKE8164 WHEN MEM ADDED IS > 8K*
1002 REM *CHANGE POKE38372 TO POKE38884 IF MEM ADDED IS < 8K*
2000 REM ****THE SUBROUTINE FOR SENDING VALUES BACK TO COMPUTER#1****
2005 POKE37138,255:REM *SETS THE DDR TO OUTPUT FOR 8 DATA LINES*
2010 POKE37139,255:REM *SETS THE DDR TO OUTPUT FOR 3 CODNTROL LINES*
2015 POKE37137,4:REM *DISABLES ALL I/O CHIPS ON INTERFACE*
2020 POKE37136,3:REM *PLACES A VALUE OF 3 INTO 8 DATA LINES*
2025 POKE37137,8:REM *SELECTS OUTCHIP2 AND LETS DATA IN 8 LINES THROUGH*
2030 POKE37137,4:REM *SEE LINE 2015*
2035 POKE37136,DAT:REM *PLACES VALUE OF DAT INTO 8 DATA LINES*
2040 POKE37137,0:REM *SELECTS OUTCHIP1 AND LETS DATA IN 8 LINES THROUGH*
2045 POKE37137,4:REM *SEE LINE 2015*
2049 REM ***LOOP TO ENSURE VIC#1 HAS RECIEVED DATA***
2050 SEL=0
2055 POKE37136,SEL:REM *PLACES VALUE OF SEL INTO 8 DATA LINES*
2060 POKE37137,8:REM *SEE LINE 2025*
2065 POKE37137,4:REM *SEE LINE 2015*
2070 POKE37138,0:REM *SETS DDR TO INPUT FOR 8 DATA LINES*
2075 POKE37137,24:REM *SELECTS INCHIP2*
2080 NUM=PEEK(37136):REM *READS VALUE IN 8 DATA LINES AND PLACES IN NUM*
2085 IF NUM=1 THEN 2095
2090 NUM=0:GOTO2080
2095 RETURN
3000 REM ****SUBROUTINE FOR READING VALUES FROM VIC#1****
3005 POKE37136,255:REM *SETS DDR TO OUTPUT FOR 8 DATA LINES*
3010 POKE37139,255:REM *SETS DDR TO OUTPUT FOR 3 CONTROL LINES*
3015 POKE37137,4:REM *DISABLES ALL I/O CHIPS ON THE INTERFACE*
```

```
3020 POKE37136,...:REM *PLACES VALUE OF ... IN THE 8 DATA LINES*
3025 POKE37137,8:REM *SELECTS OUTCHIP2 AND LETS THE DATA IN 8 LINES THROUGH*
3030 POKE37137,4:REM *SEE LINE 3015*
3035 POKE37136,0:REM *SETS DDR TO INPUT FOR 8 DATA LINES*
3040 POKE37137,24:REM *SELECTS INCHIP2*
3045 NUM=PEEK(37136):REM *READS DATA IN 8 DATA LINES INTO NUM*
3050 IF NUM=0THEN3060
3055 NUM=0:GOTO3045
3060 POKE37137,...:REM *SEE LINE 3010*
3065 POKE37137,16:REM *SELECTS INCHIP1*
3070 DAT=PEEK(37136):REM *READS VALUE IN 8 DATA LINES AND PLACES IN DAT*
3075 POKE37137,4:REM *SEE LINE 3015*
3080 POKE37136,255:REM *SEE LINE 3005*
3085 POKE37136,1:REM *PLACES VALUE OF 1 IN 8 DATA LINES*
3090 POKE37137,8:REM *SEE LINE 3025*
3095 POKE37137,4:REM *SEE LINE 3015*
3100 RETURN

READY.
```

LISTING 4

```
  REM  *****MAIN PROGRAM FOR VIC#4******
  PRINT"□":REM *CLEARS SCREEN*
  REM ****INITIAL SETUP LOOP****
  DIM X(50):DIM Y(50):N=0:SCALE=.005
  REM ***ASSIGN X AND Y VALUES TO X AND Y ARRAYS***
  X=21
  FOR Y=0TO-22STEP-1:N=N+1:X(N)=X:Y(N)=Y:NEXT Y
  Y=-22
  FOR X=21TO-22STEP-1:N=N+1:X(N)=X:Y(N)=Y:NEXT X
  X(N+1)=0:Y(N+1)=0
  REM ****DRAW PARTICLES ON SCREEN LOOP****
100 FOR I=1TON+1:X=X(I):Y=Y(I):SHP=81:COLR=2:GOSUB1000:NEXT
140 REM ****INPUT LOOP****
150 VIC=0:GOSUB2000
155 X0=DAT
160 VIC=0 GOSUB2000
165 Y0=DAT
190 REM ****DRAW TEST CHARGE ON SCREEN****
200 IFX0=0ANDY0=0THEN210
205 GOTO249
210 X=X0:Y=Y0:SHAPE=87:COLR=5:GOSUB1000
249 REM ****MAIN CALCULATION LOOP (EQUATIONS OF MOTION)****
250 SX=0:SY=0
255 FORB=1TON
260 X1=X0-X(B):Y1=Y0-Y(B):X2=X(B)-X0:Y2=Y(B)-Y0
265 ALPHA=-ATN(Y1/(X1+(X1=0)))*(X1<0)-π*((X1<0)+.5*SGN(Y1)*(X1=0))
270 SX=SX+COS(ALPHA)*SCALE/ABS(X2+(X2=0))
275 SY=SY+SIN(ALPHA)*SCALE/ABS(Y2+(Y2=0))
280 NEXTB
282 X1=X0-X(N+1):Y1=Y0-Y(N+1):X2=X(N+1)-X0:Y2=Y(N+1)-Y0
285 ALPHA=-ATN(Y1/(X1+(X1=0)))*(X1<0)-π*((X1<0)+.5*SGN(Y1)*(X1=0))
287 SX=SX+COS(ALPHA)*176*SCALE/ABS(X2+(X2=0))
290 SY=SY+SIN(ALPHA)*176*SCALE/ABS(Y2+(Y2=0))
299 REM ****OUTPUT LOOP****
300 DAT=SX:GOSUB2000
305 DAT=SY:GOSUB2000
349 REM ****RETURN TO INPUT LOOP TO AWAIT NEXT INCOMING VALUES****
350 GOTO 150
1000 POKE4580+X-(22*(22+Y)),SHP:POKE38372+X-(22*(22+Y)),COLR:RETURN
1001 REM *CHANGE POKE4580 TO POKE8164 WHEN MEM ADDED IS > 8K*    INPUT
1002 REM *CHANGE POKE38372 TO POKE38884 WHEN MEM ADDED IS > 8K*  INPUT
2000 REM ****THE SUBROUTINE FOR SENDING VALUES BACK TO COMPUTER#1****
2005 POKE37138,255:REM *SETS THE DDR TO OUTPUT FOR 8 DATA LINES*
2010 POKE37139,255:REM *SETS THE DDR TO OUTPUT FOR 3 CODNTROL LINES*
2015 POKE37137,4:REM *DISABLES ALL I/O CHIPS ON INTERFACE*
2020 POKE37136,3:REM *PLACES A VALUE OF 3 INTO 8 DATA LINES*
2025 POKE37137,8:REM *SELECTS OUTCHIP2 AND LETS DATA IN 8 LINES THROUGH*
2030 POKE37137,4:REM *SEE LINE 2015*
2035 POKE37136,DAT:REM *PLACES VALUE OF DAT INTO 8 DATA LINES*
2040 POKE37137,0:REM *SELECTS OUTCHIP1 AND LETS DATA IN 8 LINES THROUGH*
2045 POKE37137,4:REM *SEE LINE 2015*
2049 REM ***LOOP TO ENSURE VIC#1 HAS RECIEVED DATA***
2050 SEL=0
2055 POKE37136,SEL:REM *PLACES VALUE OF SEL INTO 8 DATA LINES*
2060 POKE37137,8:REM *SEE LINE 2025*
2065 POKE37137,4:REM *SEE LINE 2015*
2070 POKE37138,0:REM *SETS DDR TO INPUT FOR 8 DATA LINES*
2075 POKE37137,24:REM *SELECTS INCHIP2*
2080 NUM=PEEK(37136):REM *READS VALUE IN 8 DATA LINES AND PLACES IN NUM*
2085 IF NUM=1 THEN 2095
2090 NUM=0:GOTO2080
2095 RETURN
```

```
3000 REM ****SUBROUTINE FOR READING VALUES FROM VIC#1****
3005 POKE37138,255:REM *SETS DDR TO OUTPUT FOR 8 DATA LINES*
3010 POKE37139,255:REM *SETS DDR TO OUTPUT FOR 3 CONTROL LINES*
3015 POKE37137,4:REM *DISABLES ALL I/O CHIPS ON THE INTERFACE*
3021 POKE37136,VIC:REM *PLACES VALUE OF VIC IN THE 8 DATA LINES*
3025 POKE37137,8:REM *SELECTS OUTCHIP1 AND LETS THE DATA IN 8 LINES THROUGH*
3030 POKE37137,4:REM *SEE LINE 3015*
3035 POKE37138,0:REM *SETS DDR TO INPUT FOR 8 DATA LINES*
3040 POKE37137,24:REM *SELECTS INCHIP2*
3045 NUM=PEEK(37136):REM *READS DATA IN 8 DATA LINES INTO NUM*
3050 IF NUM=3THEN3060
3055 NUM=0:GOTO3045
3060 POKE37137,4:REM *SEE LINE 3015*
3065 POKE37137,16:REM *SELECTS INCHIP1*
3070 DAT=PEEK(37136):REM *READS VALUE IN 8 DATA LINES AND PLACES IN DAT*
3075 POKE37137,4:REM *SEE LINE 3015*
3080 POKE37138,255:REM *SEE LINE 3005*
3085 POKE37136,1:REM *PLACES VALUE OF 1 IN 8 DATA LINES*
3090 POKE37137,8:REM *SEE LINE 3025*
3095 POKE37137,4:REM *SEE LINE 3015*
3100 RETURN

READY.
```

BIBLIOGRAPHY

[1] The Wide Bandwidth Crosslink register was invented and developed by Captain James C. Lyke. He submitted it to the Air Force for an OK to send for a patent. The Air Force gave it invention #19566, and submitted it for a patent. For further information concerning the WBCR contact Captain Lyke @ (505)-844-9118 or write to him @ 1501 Tramway Blvd. NE #200. Albuquerque New Mexico 87112.

[2] The idea for this program came from Captain Lyke. He found out about it from an article in the Journal of Applied Physics Volume 34. Number 12. December 1963. pgs 3505 to 3508. The article was entitled Charged Particles in a Logarithmic Potential, and was written by R H Hooverman.